CLAUSES

1. A method of depositing a silicon carbide film, the method comprising:

providing a substrate;

flowing a first organo-silicon precursor onto the substrate;

flowing a second organo-silicon precursor onto the substrate, wherein the first organo-silicon precursor is different from the second organo-silicon precursor, and wherein the first organo-silicon precursor and the second organo-silicon precursor are flowed together onto the substrate; and

introducing from a source gas one or more radicals in a substantially low energy state to react with the first and the second organo-silicon precursors to deposit the silicon carbide film on the substrate.

2. The method of claim 1, wherein the silicon carbide film is doped with nitrogen and/or oxygen.

3. The method of claim 2, wherein the silicon carbide film is a nitrogen doped silicon carbide film, the first organo-silicon and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-nitrogen bonds.

4. The method of claim 2, wherein the silicon carbide film is an oxygen doped silicon carbide film, the first organo-silicon precursor and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-oxygen bonds.

5. The method of claim 2, wherein the silicon carbide film is an oxygen and nitrogen doped silicon carbide film, the first organo-silicon precursor having one or more silicon-oxygen bonds and the second organo-silicon precursor having one or more silicon-nitrogen bonds.

6. The method of claim 1, wherein introducing the one or more radicals comprises exposing the source gas to a remote plasma.

7. The method of any of claims 1-6, wherein a ratio of the flow rates between the first organo-silicon precursor and the second organo-silicon precursor is between about 1:1 and about 2:1.

8. The method of any of claims 1-6, wherein a ratio of the flow rates between the first organo-silicon precursor and the second organo-silicon precursor is greater than about 2:1.

9. The method of any of claims 1-6, wherein each of the first organo-silicon precursor and the second organo-silicon precursor has one or more silicon-hydrogen bonds and/or silicon-silicon bonds.

10. The method of any of claims 1-6, wherein the radicals are produced from a source gas selected from the group consisting of: nitrogen, hydrogen, ammonia, and an amine.

11. The method of any of claims 1-6, wherein the silicon carbide film has a varying concentration of oxygen and nitrogen between a lower surface and an upper surface of the film.

12. The method of any of claims 1-6, wherein the substrate comprises exposed copper, the method further comprising forming a nitrogen doped silicon carbide film directly over the exposed copper.

13. The method of any of claims 1-6, wherein one of the first or the second organo-silicon precursors are cyclic siloxanes.

14. The method of any of claims 1-6, wherein one of the first or the second organo-silicon precursors are alkoxy silanes.

15. The method of any of claims 1-6, wherein one of the first or the second organo-silicon precursors are alkyl silanes.

16. An apparatus for depositing a silicon carbide film on a substrate, the apparatus comprising:

a reaction chamber comprising the substrate;

a plasma source coupled to the reaction chamber and configured to generate a plasma outside the reaction chamber;

one or more first gas inlets coupled to the reaction chamber;

a second gas inlet coupled to the reaction chamber; and

a controller comprising instructions for performing the following operations:

(a) flowing a first organo-silicon precursor through the one or more first gas inlets into the reaction chamber;

(b) flowing a second organo-silicon precursor through the one or more first gas inlets into the reaction chamber to mix with the first organo-silicon precursor, wherein the second organo-silicon precursor is different from the first organo-silicon precursor;

(b) providing one or more radical species in a substantially low energy state from the plasma in the plasma source; and

(c) flowing the one or more radical species through the second gas inlet into the reaction chamber to react with the first organo-silicon precursor and the second organo-silicon precursor to form the silicon carbide film on the substrate.

17. The apparatus of claim 16, wherein the radical species is produced from a source gas selected from the group consisting of: nitrogen, hydrogen, ammonia, and an amine.

18. The apparatus of claim 16, wherein the silicon carbide film is doped with nitrogen and/or oxygen.

19. The apparatus of claim 18, wherein the silicon carbide film is a nitrogen doped silicon carbide film, the first organo-silicon precursor and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-nitrogen bonds.

20. The apparatus of claim 18, wherein the silicon carbide film is an oxygen doped silicon carbide film, the first organo-silicon precursor and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-oxygen bonds.

21. The apparatus of claim 18, wherein the silicon carbide film is an oxygen and nitrogen doped silicon carbide film, the first organo-silicon precursor having one or more silicon-oxygen bonds and the second organo-silicon precursor having one or more silicon-nitrogen bonds.

22. The apparatus of any of claims 16-21, wherein the controller is configured to flow each of the first and the second organo-silicon precursor at flow rates having a ratio of between about 1:1 and about 2:1.

23. The apparatus of any of claims 16-21, wherein each of the first organo-silicon precursor and the second organo-silicon precursor has one or more silicon-hydrogen bonds and/or silicon-silicon bonds.

24. The apparatus of any of claims 16-21, wherein one of the first or the second organo-silicon precursors are cyclic siloxanes.

25. The apparatus of any of claims 16-21, wherein one of the first or the second organo-silicon precursors are alkoxy silanes.

26. The apparatus of any of claims 16-21, wherein one of the first or the second organo-silicon precursors are alkyl silanes.

CLAIMS

1. A method of depositing a silicon-containing ~~carbide~~ film on a substrate, the method comprising:

providing a substrate;

~~flowing a first organo-silicon precursor onto~~ exposing the substrate to at least one silicon-containing precursor, each of the at least one silicon-containing precursor having (i) at least one of one or more silicon-hydrogen bonds and silicon-silicon bonds and (ii) at least one of one or more silicon-oxygen bonds and one or more silicon-carbon bonds;

~~flowing a second organo-silicon precursor onto~~exposing the substrate to a reactant to react with the silicon-containing precursor and form at least a portion of a silicon-containing film~~, wherein the first organo-silicon precursor is different from the second organo-silicon precursor, and wherein the first organo-silicon precursor and the second organo-silicon precursor are flowed together onto the substrate~~; and

~~introducing radicals from a source gas generated from a plasma source, wherein the radicals react with the first and the second organo-silicon precursors to deposit the silicon carbide film on the substrate under conditions in which all or substantially all the radicals have sufficient energy to break one or both of silicon-hydrogen bonds and silicon-silicon bonds but preserve silicon-oxygen, silicon-nitrogen, and/or silicon-carbon bonds, the source gas being selected from a group consisting of: hydrogen, ammonia, and amine~~alternating between exposing of the substrate to the silicon-containing precursor and the exposing of the substrate to the reactant in cycles until a desired thickness of the silicon-containing film is deposited,

wherein the reactant comprises radicals of hydrogen generated from igniting a plasma outside of a chamber housing the substrate, and

wherein the radicals of hydrogen reacts with the silicon-containing precursor under conditions that selectively break one or both of the silicon-hydrogen bonds and the silicon-silicon bonds but preserve the silicon-oxygen bonds and the silicon-carbon bonds.

~~2. The method of claim 1, wherein the silicon carbide film is doped with nitrogen and/or oxygen.~~

~~3. The method of claim 2, wherein the silicon carbide film is a nitrogen doped silicon carbide film, the first organo-silicon and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-nitrogen bonds.~~

~~4. The method of claim 2, wherein the silicon carbide film is an oxygen doped silicon carbide film, the first organo-silicon precursor and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-oxygen bonds.~~

~~5. The method of claim 2, wherein the silicon carbide film is an oxygen and nitrogen doped silicon carbide film, the first organo-silicon precursor having one or more silicon-oxygen bonds and the second organo-silicon precursor having one or more silicon-nitrogen bonds.~~

~~6. The method of claim 1, wherein the all or substantially all the radicals having sufficient energy include at least 90% of the radicals being in a ground state.~~

~~7. The method of claim 1, wherein the reaction occurs in a reaction space adjacent to the substrate and remote from the plasma source~~

~~8. The method of claim 1, wherein each of the first organo-silicon precursor and the second organo-silicon precursor has one or more silicon-hydrogen bonds and/or silicon-silicon bonds.~~

~~9. The method of claim 1, wherein the source gas includes hydrogen.~~

~~10. The method of claim 1, wherein the silicon carbide film has a varying concentration of oxygen and nitrogen between a lower surface and an upper surface of the film.~~

2. The method of claim 1, wherein a plasma is ignited during the exposing of the substrate to the reactant.

3. The method of claim 2, wherein the plasma is generated remotely.

4. The method of claim 1, wherein the silicon-containing film comprises oxygen and silicon.

5. The method of claim 1, wherein the silicon-containing film comprises silicon carbide doped with oxygen.

6. The method of claim 1, wherein the at least one silicon-containing precursor is selected from the group consisting of pentamethyldisiloxane (PMDSO), tetramethyldisiloxane (TMDSO), hexamethyltrisiloxane, and heptamethyltrisiloxane.

7. The method of claim 1, wherein a chamber housing the substrate is purged between exposing the substrate to the silicon-containing precursor and exposing the substrate to the reactant.

8. The method of claim 1, wherein the at least one silicon-containing precursor further comprises an organo-silicon precursor.

9. The method of claim 8, wherein the organo-silicon precursor is selected from the group consisting of siloxanes, alkoxy silanes, and alkylsilanes.

10. The method of claim 9, wherein the organo-silicon precursor selected is a caged siloxane.

11. The method of claim 9, wherein the organo-silicon precursor selected is a linear siloxane.

12. The method of claim 1, wherein the at least one silicon-containing precursor comprising a disiloxane or trisiloxane.

13. The method of claim 1, wherein the at least one silicon-containing precursor comprises a caged siloxane.

~~11. An apparatus for depositing a silicon carbide film on a substrate, the apparatus comprising:~~

~~a reaction chamber comprising the substrate;~~

~~a plasma source coupled to the reaction chamber and configured to generate a plasma outside the reaction chamber;~~

~~one or more first gas inlets coupled to the reaction chamber;~~

~~a second gas inlet coupled to the reaction chamber; and~~

~~a controller comprising instructions for performing the following operations:~~

~~(a) flowing a first organo-silicon precursor through the one or more first gas inlets into the reaction chamber;~~

~~(b) flowing a second organo-silicon precursor through the one or more first gas inlets into the reaction chamber to mix with the first organo-silicon precursor, wherein the second organo-silicon precursor is different from the first organo-silicon precursor;~~

~~(c) generating radical species from a source gas in the plasma source; and~~

~~(d) flowing the radical species through the second gas inlet into the reaction chamber, wherein the radical species react with the first organo-silicon precursor and the second organo-silicon precursor in a reaction space adjacent to the substrate to form the silicon carbide film on the substrate under conditions in which all or substantially all the radical species have sufficient energy to break one or both of silicon-hydrogen bonds and silicon-silicon bonds but preserve silicon-oxygen, silicon-nitrogen, and/or silicon-carbon bonds, the source gas being selected from a group consisting of: hydrogen, ammonia, and amine.~~

~~12. The apparatus of claim 11, wherein the radical species are produced from a source gas of hydrogen.~~

~~13. The apparatus of claim 11, wherein the silicon carbide film is doped with nitrogen and/or oxygen.~~

~~14. The apparatus of claim 13, wherein the silicon carbide film is a nitrogen doped silicon carbide film, the first organo-silicon precursor and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-nitrogen bonds.~~

~~15. The apparatus of claim 13, wherein the silicon carbide film is an oxygen doped silicon carbide film, the first organo-silicon precursor and the second organo-silicon precursor each having different ratios of silicon-carbon bonds to silicon-oxygen bonds.~~

~~16. The apparatus of claim 13, wherein the silicon carbide film is an oxygen and nitrogen doped silicon carbide film, the first organo-silicon precursor having one or more silicon-oxygen bonds and the second organo-silicon precursor having one or more silicon-nitrogen bonds.~~

~~17. The apparatus of claim 11, wherein the controller is configured to flow each of the first and the second organo-silicon precursor at flow rates having a ratio of between about 1:1 and about 2:1.~~

~~18. The apparatus of claim 11, wherein each of the first organo-silicon precursor and the second organo-silicon precursor has one or more silicon-hydrogen bonds and/or silicon-silicon bonds.~~

~~19. The apparatus of claim 11, wherein one of the first or the second organo-silicon precursors are cyclic siloxanes.~~

~~20. The apparatus of claim 11, wherein one of the first or the second organo-silicon precursors are alkoxy silanes.~~

~~21. The apparatus of claim 11, wherein one of the first or the second organo-silicon precursors are alkyl silanes.~~