CLAIMS

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

(a) providing the substrate to a reaction chamber;

(b) flowing one or more silicon-containing precursors to the substrate, wherein each of the one or more silicon-containing precursors have (i) one or more silicon-hydrogen bonds and/or silicon-silicon bonds, (ii) one or more silicon-carbon bonds, silicon-nitrogen bonds, and/or silicon-oxygen bonds, (iii) no carbon-oxygen bonds, and (iv) no carbon-nitrogen bonds;

(c) flowing a source gas into a plasma source;

(d) generating, from the source gas, radicals of hydrogen in the plasma source;

(e) flowing the radicals of hydrogen onto the substrate, wherein all or at least 90% of the radicals are radicals of hydrogen in the ground state that react with the one or more silicon-containing precursors under conditions that break the silicon-containing precursor's silicon-hydrogen bonds or silicon-silicon bonds but preserve the silicon-containing precursor's silicon-carbon bonds, silicon-nitrogen bonds, and/or silicon-oxygen bonds; and

(f) forming, from the reaction, a silicon oxycarbide (SiOC) film, silicon nitricarbide (SiNC) film, or silicon oxynitricarbide (SiONC) film on the substrate, wherein the one or more silicon-containing precursors include an alkylcarbosilane, a siloxane, a silazane, or any combination thereof when forming SiOC film, SiNC film, or SiONC film, wherein the SiOC film, SiNC film, or SiONC film has a conformality of at least 90%.

2. The method of claim 1, further comprising flowing a co-reactant with the one or more silicon-containing precursors, wherein the co-reactant includes at least one of carbon dioxide, carbon monoxide, water, methanol, oxygen, ozone, nitrogen, nitrous oxide, ammonia, methane, ethane, acetylene, ethylene, and diborane.

3. The method of claim 2, wherein the co-reactant includes one or both of carbon dioxide and oxygen.

4. The method of claim 1, wherein the silicon oxycarbide film, silicon nitricarbide film or silicon oxynitricarbide film is formed without performing atomic layer deposition.

5. The method of claim 1, wherein the one or more silicon containing precursors have no alkoxy groups (-C-O-R), where R is an organic moiety, and no amine groups (-C-NR1R2), where R1 and R2 are each independently hydrogen or an organic moiety.

6. The method of claim 1, wherein the one or more silicon-containing precursors include a cyclic siloxane.

7. The method of claim 6, wherein the cyclic siloxane is selected from the group consisting of heptamethylcyclotetrasiloxane and tetramethylcyclotetrasiloxane.

8. The method of claim 1, wherein the one or more silicons containing precursors include a linear siloxane.

9. The method of claim 8, wherein the linear siloxane is selected from the group consisting of disiloxanes and trisiloxanes.

10. The method of claim 1, wherein the one or more silicon-containing precursors include an alkyl silane.

11. The method of claim 1, wherein the one or more silicon-containing precursors include a silazane.

12. The method of claim 1, wherein during (b) through (e), no compound containing a carbon-oxygen bond or a carbon-nitrogen bond is provided to the substrate.

13. The method of claim 1, wherein generating the radicals of hydrogen comprises exposing the source gas to a remote plasma.

14. The method of claim 13, further comprising producing the remote plasma from an RF power source or a microwave power source.

15. The method of any of claims 1, wherein the ratio of silicon-oxygen or silicon-nitrogen bonds to silicon-carbon bonds in the silicon oxycarbide film, the silicon nitricarbide film, or the silicon oxynitricarbide film is between about 3:1 and about 0.5:1.

16. The method of claim 1, wherein the substrate comprises a transistor having a gate electrode, the method further comprising forming the silicon oxycarbide film, the silicon nitricarbide film, or the silicon oxynitricarbide film on one or more sidewalls of the gate electrode.

17. The method of claims 1, wherein the silicon oxycarbide film, the silicon nitricarbide film, or the silicon oxynitricarbide film comprises an ultralow-k dielectric thin film.