~~THE FOLLOWING IS CLAIMED~~

~~1) A method for forming a carbon-doped silicon oxide film via a plasma enhanced ALD process, the method comprising:~~

~~a) providing a substrate comprising a surface feature in a reactor;~~

~~b) heating the reactor to one or more temperatures ranging up from about 20°C to about 400°C and, optionally, maintaining the reactor at a pressure of 100 torr or less;~~

~~c) introducing into the reactor at least one silicon precursor having two Si-C-Si linkages selected from the group consisting of 1-chloro-1,3-disilacyclobutane, 1-bromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-disilacyclobutane, 1,3-dibromo-1,3-disilacyclobutane, 1,1,3-trichloro-1,3-disilacyclobutane, 1,1,3-tribromo-1,3-disilacyclobutane, 1,1,3,3-tetrachloro-1,3-disilacyclobutane, 1,1,3,3-tetrabromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-dimethyl-1,3-disilacyclobutane, 1,3-bromo-1,3-dimethyl-1,3-disilacyclobutane, 1,1,1,3,3,5,5,5-octachloro-1,3,5-trisilapentane, 1,1,3,3,5,5-hexachloro-1,5-dimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-3,3-dimethyl-1,3,5-trisilapentane, 1,1,3,5,5-pentachloro-1,3,5-trimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-1,3,5-trisilapentane, and 1,1,5,5-tetrachloro-1,3,5-trisilapentane, 1-iodo-1,3-disilacyclobutane, 1,1-diiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-disilacyclobutane, 1,1,3-triiodo-1,3-disilacyclobutane, 1,1,3,3-tetraiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-dimethyl-1,3-disilacyclobutane, 1-chloro-1,3,5-trisilapentane, 1,5-dichloro-1,3,5-trisilapentane, 1-bromo-1,3,5-trisilapentane, 1,5-dibromo-1,3,5-trisilapentane, 1-iodo-1,3,5-trisilapentane, and 1,5-diiodo-1,3,5-trisilapentane to anchor a chemisorbed layer on the substrate;~~

~~d) purging the reactor of any unconsumed precursors and/or reaction by-products from step c, with an inert gas;~~

e) providing a plasma selected from the group consisting of hydrogen, inert gas, and a mixture thereof into the reactor to react with the chemisorbed layer to form a silicon carbide film;

f) purging the reactor of any reaction by-products from step e with an inert gas;

g) repeating steps c to f as necessary to bring the silicon carbide film to a predetermined thickness;

h) exposing the resulting silicon carbide film to an oxygen source at one or more temperatures ranging from about ambient temperature to 1000°Cto convert the silicon carbide film into a carbon doped silicon oxide film,

wherein the carbon-doped silicon oxide film has a carbon content ranging between about 20 at. % and about 40 at. %.

2) A film formed according to the method of claim 1 having a k of 4 or less, and a carbon content of at least about 30 at. %.

3) A film formed according to the method of claim 1 having an etch rate of no greater than about 0.5 times that of thermal silicon oxide as measured in about 0.5 wt. % hydrofluoric acid in deionized water.

4) A film formed according to the method of claim 1 having an etch rate of no greater than about 0.1 times that of thermal silicon oxide as measured in about 0.5 wt. % hydrofluoric acid in deionized water.

5) A film formed according to the method of claim 1 having an etch rate of no greater than about 0.05 times that of thermal silicon oxide as measured in about 0.5 wt. % hydrofluoric acid in deionized water.

6) A film formed according to the method of claim 1 having an etch rate of no greater than about 0.01 times that of thermal silicon oxide as measured in about 0.5 wt. % hydrofluoric acid in deionized water.

7) A film formed according to the method of claim 1 wherein the carbon doped silicon oxide film is characterized such that a depth of 50 Å or less of the carbon doped silicon oxide film would be damaged following an oxygen ashing process.

8) The film formed according to the method of claim 7 wherein a depth of 20 Å or less would be damaged following an oxygen ashing process.

9) The film formed according to the method of claim 8 wherein a depth of 10 Å or less would be damaged following an oxygen ashing process.

10) The film formed according to the method of claim 9 wherein a depth of 5 Å or less would be damaged following an oxygen ashing process.

11) The method of Claim 1 further comprising performing a thermal anneal on the carbon doped silicon oxide film at temperatures from 300 to 1000°C.

12) The method of Claim 1 further comprising performing a plasma treatment on the carbon doped silicon oxide film with an inert gas plasma or hydrogen/inert plasma at a temperature ranging between 25°C and 600°C.

13) A method for depositing silicon carbide film onto at least a surface of a substrate comprising:

providing the substrate in a reactor;

heating the reactor to one or more temperatures ranging from about 400°C to about 600°C;

introducing into the reactor a precursor selected from the group consisting of 1,1,1,3,3,3-hexachloro-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2-methyl-1,3-disilapropane, 1,1,3,3,3-hexachloro-2,2-dimethyl-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2-ethyl-1,3-disilapropane, 1-chloro-1,3-disilacyclobutane, 1-bromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-disilacyclobutane, 1,3-dibromo-1,3-disilacyclobutane, 1,1,3-trichloro-1,3-disilacyclobutane, 1,1,3-tribromo-1,3-disilacyclobutane, 1,1,3,3-tetrachloro-1,3-disilacyclobutane, 1,1,3,3-tetrabromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-dimethyl-1,3-disilacyclobutane, 1,3-bromo-1,3-dimethyl-1,3-disilacyclobutane, 1,1,1,3,3,5,5,5-octachloro-1,3,5-trisilapentane, 1,1,3,3,5,5-hexachloro-1,5-dimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-3,3-dimethyl-1,3,5-trisilapentane, 1,1,3,5,5-pentachloro-1,3,5-trimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-1,3,5-trisilapentane, 1,1,5,5-tetrachloro-1,3,5-trisilapentane, 1-iodo-1,3-disilacyclobutane, 1,1-diiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-disilacyclobutane, 1,1,3-triiodo-1,3-disilacyclobutane, 1,1,3,3-tetraiodo-1,3-disilacyclobutane, and 1,3-diiodo-1,3-dimethyl-1,3-disilacyclobutane, 1-chloro-1,3,5-trisilapentane, 1,5-dichloro-1,3,5-trisilapentane, 1-

bromo-1,3,5-trisilapentane, 1,5-dibromo-1,3,5-trisilapentane, 1-iodo-1,3,5-trisilapentane, and 1,5-diiodo-1,3,5-trisilapentane, and;

introducing into the reactor a plasma comprising a hydrogen source to react with at least a portion of the precursor to form a silicon carbide film.

14) The method according to claim 13, further comprising treating the silicon carbide film with inert gas plasma or hydrogen/inert plasma at a temperature ranging between 25°C and 600°C.

15) A method for forming a carbon-doped silicon oxide film via a plasma enhanced ALD process, the method comprising:

a) providing a substrate comprising a surface feature in a reactor;

b) heating the reactor to one or more temperatures ranging up to about 550°C and, optionally, maintaining the reactor at a pressure of 100 torr or less;

c) introducing into the reactor at least one silicon precursor having one Si-C-Si linkage selected from the group consisting of 1,1,1,3,3,3-hexachloro-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2-methyl-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2,2-dimethyl-1,3-disilapropane, and 1,1,1,3,3,3-hexachloro-2-ethyl-1,3-disilapropane to form a chemisorbed layer on the substrate;

d) purging the reactor of any unconsumed precursors and/or reaction by-products from step c, with an inert gas;

e) providing a plasma comprising hydrogen into the reactor to react with the chemisorbed layer to form a silicon carbide film;

f) purging the reactor of any reaction by-products from step e with an inert gas;

g) repeating steps c to f as necessary to bring the silicon carbide film to a predetermined thickness;

h) exposing the resulting silicon carbide film to an oxygen source at one or more temperatures ranging from about ambient temperature to 1000°C, preferably from about 100° to 400°C,

~~to convert the silicon carbide film into a carbon doped silicon oxide film; and~~

~~wherein the carbon-doped silicon oxide film has a carbon content ranging between about 20 at. % and about 40 at. %.~~

~~16) The method according to claim 15, further comprising treating the carbon doped silicon oxide film with a spike anneal at temperatures from 400 to 1000°C.~~

~~17) The method according to claim 15, further comprising exposing the carbon doped silicon oxide film with a UV light source.~~

~~18) The method according to claims 1 further comprising exposing the carbon doped silicon oxide film to an organoaminosilane, or a chlorosilane, having one or both of a Si-Me group and a Si-H group.~~

THE FOLLOWING IS CLAIMED

1. A method for forming a carbon-doped silicon oxide film via a plasma enhanced ALD process, the method comprising:

a) providing a substrate comprising a surface feature in a reactor;

b) heating the reactor to one or more temperatures ranging up from 20°C to 400°C and maintaining the reactor at a pressure of 100 torr or less;

c) introducing into the reactor at least one silicon precursor having two Si-C-Si linkages selected from the group consisting of 1-chloro-1,3-disilacyclobutane, 1-bromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-disilacyclobutane, 1,3-dibromo-1,3-disilacyclobutane, 1,1,3-trichloro-1,3-disilacyclobutane, 1,1,3-tribromo-1,3-disilacyclobutane, 1,1,3,3-tetrachloro-1,3-disilacyclobutane, 1,1,3,3-tetrabromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-dimethyl-1,3-disilacyclobutane, 1,3-bromo-1,3-dimethyl-1,3-disilacyclobutane, 1,1,1,3,3,5,5,5-octachloro-1,3,5-trisilapentane, 1,1,3,3,5,5-hexachloro-1,5-dimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-3,3-dimethyl-1,3,5-trisilapentane, 1,1,3,5,5-pentachloro-1,3,5-trimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-1,3,5-trisilapentane, 1,1,5,5-tetrachloro-1,3,5-trisilapentane, 1-iodo-1,3-disilacyclobutane, 1,1-diiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-disilacyclobutane, 1,1,3-triiodo-1,3-disilacyclobutane, 1,1,3,3-tetraiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-dimethyl-1,3-disilacyclobutane, 1-chloro-1,3,5-trisilapentane, 1,5-dichloro-1,3,5-trisilapentane, 1-bromo-1,3,5-trisilapentane, 1,5-dibromo-1,3,5-trisilapentane, 1-iodo-1,3,5-trisilapentane, and 1,5-diiodo-1,3,5-trisilapentane to anchor a chemisorbed layer on the substrate;

d) purging the reactor of any unconsumed precursors and/or reaction by-products from step c, with an inert gas;

e) providing a plasma selected from the group consisting of hydrogen, inert gas, and a mixture thereof into the reactor to react with the chemisorbed layer to form a silicon carbide film;

f) purging the reactor of any reaction by-products from step e with an inert gas;

g) repeating steps c to f to bring the silicon carbide film to a predetermined thickness;

h) exposing the resulting silicon carbide film to an oxygen source at one or more temperatures ranging from ambient temperature to 1000°C to convert the silicon carbide film into a carbon doped silicon oxide film,

wherein the carbon-doped silicon oxide film has a carbon content ranging between 20 at. % and 40 at. %.

2. The method of claim 1, wherein the carbon-doped silicon oxide film has a dielectric constant k of 4 or less, and a carbon content of at least 30 at. %.

3. The method of claim 1, wherein the carbon-doped silicon oxide film has an etch rate of no greater than 0.5 times that of thermal silicon oxide as measured in 0.5 wt. % hydrofluoric acid in deionized water.

4. The method of claim 1 , wherein the carbon-doped silicon oxide film has an etch rate of no greater than 0.1 times that of thermal silicon oxide as measured in 0.5 wt. % hydrofluoric acid in deionized water.

5. The method of claim 1 , wherein the carbon-doped silicon oxide film has an etch rate of no greater than 0.05 times that of thermal silicon oxide as measured in 0.5 wt. % hydrofluoric acid in deionized water.

6. The method of claim 1 , wherein the carbon-doped silicon oxide film has an etch rate of no greater than 0.01 times that of thermal silicon oxide as measured in 0.5 wt. % hydrofluoric acid in deionized water.

7. The method of Claim 1 further comprising performing a thermal anneal on the carbon doped silicon oxide film at temperatures from 300 to 1000°C.

8. The method of Claim 1 further comprising performing a plasma treatment on the carbon doped silicon oxide film with an inert gas plasma or hydrogen/inert plasma at a temperature ranging between 25°C and 600°C.

9. A method for depositing silicon carbide film onto at least a surface of a substrate comprising:

providing the substrate in a reactor;

heating the reactor to one or more temperatures ranging from 400°C to 600°C;

introducing into the reactor a precursor selected from the group consisting of 1,1,1,3,3,3-hexachloro-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2-methyl-1,3-disilapropane, 1,1,3,3,3-hexachloro-2,2-dimethyl-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2-ethyl-1,3-disilapropane, 1-chloro-1,3-disilacyclobutane, 1-bromo-1,3-disilacyclobutane, 1,3-dichloro-1,3-disilacyclobutane, 1,3-dibromo-1,3-disilacyclobutane, 1,1,3-trichloro-1,3-disilacyclobutane, 1,1,3-tribromo-1,3-disilacyclobutane, 1,1,3,3-tetrachloro-1,3-disilacyclobutane, 1,1,3,3-tetrabromo-1,3-disilacyclobutane, 1,3-dichloro-

1,3-dimethyl-1,3-disilacyclobutane, 1,3-bromo-1,3-dimethyl-1,3-disilacyclobutane, 1,1,1,3,3,5,5,5-octachloro-1,3,5-trisilapentane, 1,1,3,3,5,5-hexachloro-1,5-dimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-3,3-dimethyl-1,3,5-trisilapentane, 1,1,3,5,5-pentachloro-1,3,5-trimethyl-1,3,5-trisilapentane, 1,1,1,5,5,5-hexachloro-1,3,5-trisilapentane, 1,1,5,5-tetrachloro-1,3,5-trisilapentane, 1-iodo-1,3-disilacyclobutane, 1,1-diiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-disilacyclobutane, 1,1,3-triiodo-1,3-disilacyclobutane, 1,1,3,3-tetraiodo-1,3-disilacyclobutane, 1,3-diiodo-1,3-dimethyl-1,3-disilacyclobutane, 1-chloro-1,3,5-trisilapentane, 1,5-dichloro-1,3,5-trisilapentane, 1-bromo-1,3,5-trisilapentane, 1,5-dibromo-1,3,5-trisilapentane, 1-iodo-1,3,5-trisilapentane, and 1,5-diiodo-1,3,5-trisilapentane, and;

introducing into the reactor a plasma comprising a hydrogen source to react with at least a portion of the precursor to form a silicon carbide film.

10. The method according to claim 9, further comprising treating the silicon carbide film with inert gas plasma or hydrogen/inert plasma at a temperature ranging between 25°C and 600°C.

11. A method for forming a carbon-doped silicon oxide film via a plasma enhanced ALD process, the method comprising:

a) providing a substrate comprising a surface feature in a reactor;

b) heating the reactor to one or more temperatures ranging up to 550°C and maintaining the reactor at a pressure of 100 torr or less;

c) introducing into the reactor at least one silicon precursor having one Si-C-Si linkage selected from the group consisting of 1,1,1,3,3,3-hexachloro-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2-methyl-1,3-disilapropane, 1,1,1,3,3,3-hexachloro-2,2-dimethyl-1,3-disilapropane, and 1,1,1,3,3,3-hexachloro-2-ethyl-1,3-disilapropane to form a chemisorbed layer on the substrate;

d) purging the reactor of any unconsumed precursors and/or reaction by-products from step c, with an inert gas;

e) providing a plasma comprising hydrogen into the reactor to react with the chemisorbed layer to form a silicon carbide film;

f) purging the reactor of any reaction by-products from step e with an inert gas;

g) repeating steps c to f to bring the silicon carbide film to a predetermined thickness;

h) exposing the resulting silicon carbide film to an oxygen source at one or more temperatures ranging from ambient temperature to 1000°C to convert the silicon carbide film into a carbon doped silicon oxide film; and

wherein the carbon-doped silicon oxide film has a carbon content ranging between 20 at. % and 40 at. %.

12. The method according to claim 11, further comprising treating the carbon doped silicon oxide film with a spike anneal at temperatures from 400 to 1000°C.

13. The method according to claim 11, further comprising exposing the carbon doped silicon oxide film with a UV light source.

14. The method according to claims 1, further comprising exposing the carbon doped silicon oxide film to an organoaminosilane, or a chlorosilane, having one or both of a Si-Me group and a Si-H group.