CLAIMS

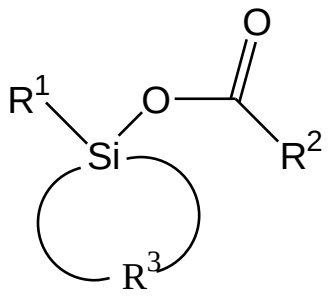
1. A method for producing a dielectric film represented by the formula $Si_vO_wC_xH_yF_z$, wherein v+w+x+y+z = 100%, v is from 10 to 35 at. %, w is from 10 to 65 at. %, x is from 5 to 40 at. %, y is from 10 to 50 at. % and z is from 0 to 15 at. %, said method comprising:

providing a substrate within a reaction chamber;

introducing into the reaction chamber gaseous reagents comprising at least one structure-forming precursor comprising an silacyclic compound, wherein the silacyclic compound contains less than about 100 ppm of impurities; and

applying energy to the gaseous reagents in the reaction chamber to induce reaction of the gaseous reagents and thereby deposit a film on the substrate,

wherein the silacyclic compound comprises a compound having the following Formula I:



(I)

wherein R^1 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, a linear or branched C_2 to C_{10} alkenyl group, a linear or branched C_2 to C_{10} alkynyl group, a C_3 to C_{10} cyclic alkyl group, a C_3 to C_{10} hetero-cyclic alkyl group, a C_5 to C_{10} aryl or aralkyl group, and a C_3 to C_{10} hetero-aryl group; R^2 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, a linear or branched C_2 to C_{10} alkenyl group, a linear or branched C_2 to C_{10} alkynyl group, a C_3 to C_{10} cyclic alkyl group, a C_3 to C_{10} hetero-cyclic alkyl group, a C_5 to C_{10} aryl or aralkyl group, and a C_3 to C_{10} hetero-aryl group; and R^3 is selected from a C_3 to C_{10} alkyl di-radical which forms a four-membered, five-membered, or six-membered saturated or unsaturated cyclic ring with the Si atom.

2. The method of claim 1 wherein the gaseous reagents further comprise a structure forming reagent comprising a hardening additive selected from tetraethoxysilane and tetramethoxysilane.

3. The method of claim 1 wherein the silacyclic compound comprises at least one compound selected from the group consisting of 1-methyl-1-acetoxy-1-silacyclopentane, 1-methyl-1-propionoxy-1-silacyclopentane, 1-methyl-1-acetoxy-1-silacyclobutane, 1-methyl-1-propionoxy-1-silacyclobutane, 1-methyl-1-acetoxy-1-silacyclohexane, 1-methyl-1-propionoxy-1-silacyclohexane, 1-ethyl-1-acetoxy-1-silacyclopentane, 1-ethyl-1-propionoxy-1-silacyclopentane, 1-ethyl-1-acetoxy-1-silacyclobutane, 1-ethyl-1-propionoxy-1-silacyclobutane, 1-ethyl-1-acetoxy-1-silacyclohexane, 1-ethyl-1-propionoxy-1-silacyclohexane and combinations thereof.

4. The method of claim 3 wherein the silacyclic compound comprises 1-methyl-1-acetoxy-1-silacyclopentane.

5. The method of claim 1 wherein the method is plasma enhanced chemical vapor deposition.

6. The method of claim 1 wherein the gaseous reagents further comprise at least one oxidant selected from the group consisting of O_2, N_2O, NO, NO_2, CO_2, water, H_2O_2, ozone, and mixtures thereof, or wherein the gaseous reagents are free of an oxidant.

7. The method of claim 1 wherein the reaction chamber in the applying step further comprises at least one gas selected from He, Ar, N_2, Kr, Xe, NH_3, H_2, CO_2, or CO.

8. The method of claim 1 further comprising an additional post deposition treatment step, which comprises at least one of a thermal treatment, a UV annealing, an e-beam treatment, and a gamma radiation treatment.

9. The method of claim 8 wherein the post deposition treatment step comprises both UV annealing and thermal treatment.

10. The method of claim 1 wherein the as deposited film includes 30 at. % or higher carbon, has an elastic modulus of 13 GPa or higher; and has a film hardness of 2.0 GPa or higher.

11. The method of claim 1 wherein the as deposited film is subsequently UV cured and the cured film includes 25 at. % or higher carbon, has an elastic modulus of 15 GPa or higher, and has a hardness of 3.0 GPa or higher.

12. The method of claim 1;

wherein the gaseous reagents further comprise a porogen;

wherein the as deposited film is a preliminary film including the porogen; and wherein the method further comprises:

removing from the preliminary film at least a portion of the porogen to provide the porous dielectric film comprising pores and having a dielectric constant of 2.6 or less.

13. The method of claim 12 wherein the porogen is at least one compound selected from the group consisting of:

cyclic hydrocarbons of the general formula C_nH_{2n} where n = 4 – 14, wherein the number of carbons in the cyclic structure is between 4 and 10, and wherein one or more simple or branched hydrocarbon substituents are optionally present on the cyclic structure;

linear or branched, saturated, singly or multiply unsaturated hydrocarbons of the general formula $C_nH_{(2n+2)-2m}$ wherein n = 2 – 20 and m = 0 – n;

singly or multiply unsaturated cyclic hydrocarbons of the general formula C_nH_{2n-2p} wherein p is the number of unsaturated sites in the molecule, n = 4 – 14, the number of carbons in the cyclic structure is between 4 and 10, and wherein one or more simple or branched hydrocarbon substituents are optionally present on the cyclic structure;

bicyclic hydrocarbons of the general formula C_nH_{2n-2} wherein n = 4 – 14, the number of carbons in the bicyclic structure is between 4 and 12, and wherein one or more simple or branched hydrocarbon substituents are optionally present on the cyclic structure;

multiply unsaturated bicyclic hydrocarbons of the general formula $C_nH_{2n-(2+2m)}$ wherein m is the number of unsaturated sites in the molecule, n = 4 – 14, the number of carbons in the bicyclic structure is between 4 and 12, and wherein one or more simple or branched hydrocarbon substituents are optionally present on the cyclic structure; and

tricyclic hydrocarbons of the general formula C_nH_{2n-4} wherein n = 4 – 14, the number of carbons in the tricyclic structure is between 4 and 12, and wherein one or more simple or branched hydrocarbon substituents are optionally present on the cyclic structure.

14. The method of claim 13 wherein the porogen comprises at least one compound selected from the group consisting of cyclohexane, 1,2,4-trimethylcyclohexane, 1-methyl-4-(1-methylethyl)cyclohexane, cyclooctane, methylcyclooctane, ethylene, propylene, acetylene, neohexane, 1,3-butadiene, 2-methyl-1,3-butadiene, 2,3-dimethyl-2,3-butadiene, substituted dienes, para-cymene, cyclooctene, 1,5-cyclooctadiene, cyclohexene, vinyl-cyclohexane, dimethylcyclohexene, alpha-terpinene, pinene, limonene, vinyl-cyclohexene, norbornane, spiro-nonane, camphene, norbornene, norbornadiene, 5-ethylidene-2-norbornene, decahydronaphthalene, and adamantane.

15. The method of claim 1 wherein the film structure comprises at least one of $–CH_2–$ methylene and $–CH_2CH_2-$ ethylene bridges.