

CLAIMS

1. A method for making a dense organosilica film with improved mechanical properties, the method comprising the steps of:

- 5 providing a substrate within a reaction chamber; introducing into the reaction chamber a gaseous composition comprising at least one mono- or dialkoxysilane having the structure given in Formula (1) or (2):



- wherein R^1 is methyl, R^2 is selected from a branched or cyclic C_3 to C_{10} alkyl, preferably iso-propyl or tert-butyl, and R^3 is selected from a linear, branched or cyclic C_1 to C_{10} alkyl, preferably methyl, ethyl, propyl, iso-propyl, butyl, sec-butyl, iso-butyl, tert-butyl, or cyclohexyl;



- wherein R^4 is hydrogen or methyl, R^5 is selected from a linear, branched or cyclic C_1 to C_{10} alkyl, preferably iso-propyl or tert-butyl, and R^6 is selected from a linear, branched, or cyclic C_3 to C_{10} alkyl, preferably iso-propyl, sec-butyl, iso-butyl, cyclohexyl or tert-butyl; and
- applying energy to the gaseous composition comprising mono- or dialkoxysilane in the reaction chamber to induce reaction of the gaseous composition comprising mono- or dialkoxysilane to deposit an organosilica film on the substrate, wherein the organosilica film
- has a dielectric constant of from about 2.80 to about 3.30 and an elastic modulus of from about 7 to about 30 GPa.

2. The method of claim 1 wherein the gaseous composition comprising at least one mono- or dialkoxysilane is free of a hardening additive.

3. The method of claim 1 wherein the mono- or dialkoxysilane of Formula (1) or (2) is substantially free of one or more impurities selected from the group consisting of a halide, water, metals, and combinations thereof.

4. The method of claim 1 which is a chemical vapor deposition method.

5. The method of claim 1 which is a plasma enhanced chemical vapor deposition method.

6. The method of claim 1 wherein the gaseous composition comprising at least one mono- or dialkoxysilane comprises at least one oxidant selected from the group consisting of O₂, N₂O, NO, NO₂, CO₂, water, H₂O₂, ozone, and combinations thereof.

5 7. The method of claim 1 wherein the gaseous composition comprising at least one mono- or dialkoxysilane does not comprise an oxidant.

8. The method of claim 1 wherein in the applying step the reaction chamber contains at least one gas selected from the group consisting of He, Ar, N₂, Kr, Xe, CO₂, and
10 CO.

9. The method of claim 1 wherein the organosilica film has a refractive index (RI) of from about 1.3 to about 1.6 at 632 nm and an at. % carbon as measured by XPS of from about 10 % to about 30%.

15 10. The method of claim 1 wherein the organosilica film is deposited at a rate of from about 5 nm/min to about 700 nm/min.

11. The method of claim 8 wherein the organosilica film has a SiCH₂Si/SiO_x*1E4
20 IR ratio of from about 10 to about 30.

12. The method of claim 1 wherein the mono- or di-alkoxysilane in the gaseous composition comprises one or more precursors selected from the group consisting of iso-propyl-methyl-methoxysilane, isopropyl-methyl-ethoxysilane, n-butyl-methyl-iso-propoxysilane, iso-butyl-methyl-iso-propoxysilane, isopropyl-methyl-isopropoxysilane, sec-butylmethylmethoxysilane, sec-butylmethylethoxysilane, sec-butylmethyl-iso-propoxysilane, t-butyl-methyl-methoxysilane, t-butyl-methyl-ethoxysilane, t-butyl-methyl-isopropoxysilane, cyclohexyl-methyl-methoxysilane, cyclopentyl-methyl-methoxysilane, cyclopentyl-methyl-iso-propoxysilane, cyclohexyl-methyl-ethoxy silane, cyclohexyl-iso-propoxymethylsilane, di-iso-propoxy-dimethylsilane, di-isopropoxy-methylsilane, di-t-butoxy-dimethylsilane, di-t-butoxy-methylsilane, dicyclohexoxy-dimethylsilane, dicyclohexoxy-methylsilane, di-sec-butoxy-dimethylsilane, di-sec-butoxy-methylsilane, dicyclopentoxymethylsilane, and
30 dicyclopentoxymethylsilane.

13. The method of claim 1 wherein the mono- or dialkoxysilane in the gaseous composition comprises one or more precursors selected from the group consisting of iso-

propyl-methyl-ethoxysilane, iso-methyl-propyl-iso-propoxysilane, di-iso-propoxy-dimethylsilane, di-t-butoxy-dimethylsilane, di-sec-butoxy-dimethylsilane, dicyclohexoxy-dimethylsilane, dicyclohexoxymethylsilane, dicyclopentoxo-dimethylsilane, and dicyclopentoxymethylsilane.

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14. A gaseous composition comprising at least one mono- or dialkoxysilane having the structure given in Formula (1) or (2):



10 wherein R^1 is methyl, R^2 is selected from a branched or cyclic C_3 to C_{10} alkyl, preferably iso-propyl or tert-butyl, and R^3 is selected from a linear, branched or cyclic C_1 to C_{10} alkyl, preferably methyl, ethyl, propyl, iso-propyl, butyl, sec-butyl, iso-butyl, tert-butyl, or cyclohexyl;



15 wherein R^4 is hydrogen or methyl, R^5 is selected from a linear, branched or cyclic C_1 to C_{10} alkyl, preferably iso-propyl or tert-butyl, and R^6 is selected from a linear, branched, or cyclic C_3 to C_{10} alkyl, preferably iso-propyl, sec-butyl, iso-butyl, cyclohexyl or tert-butyl,

wherein the gaseous composition is substantially free of one or more impurities selected from the group consisting of a halide, water, metals, and combinations thereof.

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15. The gaseous composition of claim 14 wherein the at least one mono-or dialkoxysilane is selected from the group consisting of iso-propyl-methyl-methoxysilane, isopropyl-methyl-ethoxysilane, n-butyl-methyl-iso-propoxysilane, iso-butyl-methyl-iso-propoxysilane, isopropyl-methyl-isopropoxysilane, sec-butylmethoxysilane, sec-butylmethylethoxysilane, sec-butylmethyl-iso-propoxysilane, t-butyl-methyl-methoxysilane, t-butyl-methyl-ethoxysilane, t-butyl-methyl-isopropoxysilane, cyclohexyl-methyl-methoxysilane, cyclopentyl-methyl-methoxysilane, cyclopentyl-methyl-iso-propoxysilane, cyclohexyl-methyl-ethoxy silane, cyclohexyl-iso-propoxymethylsilane, di-iso-propoxy-dimethylsilane, di-isopropoxy-methylsilane, di-t-butoxy-dimethylsilane, di-t-butoxy-methylsilane, dicyclohexoxy-dimethylsilane, dicyclohexoxy-methylsilane, di-sec-butoxy-dimethylsilane, di-sec-butoxy-methylsilane, dicyclopentoxydimethylsilane, and dicyclopentoxymethylsilane.

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16. The gaseous composition of claim 14 wherein the at least one mono- or dialkoxysilane is selected from the group consisting of iso-propyl-methyl-ethoxysilane, iso-methyl-propyl-iso-propoxysilane, di-iso-propoxy-dimethylsilane, di-t-butoxy-dimethylsilane, di-sec-butoxy-dimethylsilane, dicyclohexoxy-dimethylsilane, dicyclohexoxymethylsilane, dicyclopentoxy-dimethylsilane, and dicyclopentoxymethylsilane.

17. The gaseous composition of claim 14 having less than 5 ppm of metals selected from the group consisting of Li, Na, K, Mg, Ca, Al, Fe, Fe, Ni, and Cr as measured by ICP-MS.

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18. The gaseous composition of claim 14 having less than 0.1 ppm of the metals selected from the group consisting of Li, Na, K, Mg, Ca, Al, Fe, Fe, Ni, and Cr as measured by ICP-MS.

19. The gaseous composition of claim 14 having less than 50 ppm of halides.

20. The composition of claim 19, wherein the halide is chloride ions, if present, are present at a concentration of 10 ppm or less as measured by IC.

21. The composition of claim 19, wherein the halide is chloride ions, if present, are present at a concentration of 5 ppm or less as measured by IC

22. A gaseous composition for vapor deposition of silicon-containing films comprising at least one mono- or dialkoxysilane selected from the group consisting of iso-butyl-methyl-iso-propoxysilane, isopropyl-methyl-isopropoxysilane, sec-butylmethylethoxysilane, sec-butylmethyl-iso-propoxysilane, t-butyl-methyl-isopropoxysilane, cyclohexylethoxymethylsilane, cyclohexylisopropoxymethylsilane, di-iso-propoxy-dimethylsilane, di-t-butoxy-dimethylsilane, di-sec-butoxy-dimethylsilane, dicyclohexoxy-dimethylsilane, dicyclohexoxymethylsilane, dicyclopentoxy-dimethylsilane, and dicyclopentoxymethylsilane.