Claims

1. A method for forming a pore sealing layer, the method comprising the steps of:

a. providing a substrate having a porous low dielectric constant layer in a reactor;

b. contacting the substrate with at least one organosilicon compound selected from the group consisting of 1-methyl-1-methoxy-1-silacyclopentane, 1-methyl-1-ethoxy-1-silacyclopentane, 1-methyl-1-iso-propoxy-1-silacyclopentane, 1-methyl-1-n-propoxy-1-silacyclopentane, 1-methyl-1-n-butoxy-1-silacyclopentane, 1-methyl-1-sec-butoxy-1-silacyclopentane, 1-methyl-1-iso-butoxy-1-silacyclopentane, 1-methyl-1-tert-butoxy-1-silacyclopentane, 1-methoxy-1-silacyclopentane, 1-ethoxy-1-silacyclopentane, 1-methyl-1-methoxy-1-silacyclobutane, 1-methyl-1-ethoxy-1-silacyclobutane, 1-methoxy-1-silacyclobutane, 1-ethoxy-1-silacyclobutane, 1,2-bis(dimethoymethylsilyl)methane, 1,2-bis(diethoymethylsilyl)methane, 1,2-bis(dimethoymethylsilyl)ethane, and 1,2-bis(diethoymethylsilyl)ethane, to provide an absorbed organosilicon compound on at least a portion of a surface of the porous low dielectric constant layer;

c. purging the reactor with a purge gas;

d. introducing a plasma into the reactor to react with absorbed organosilicon compound, wherein the plasma is at least one selected from nitrogen (N_2), argon (Ar), helium (He), hydrogen (H), and ammonia (NH_3), and

e. purging the reactor with a purge gas; wherein steps b through e are repeated until a desired thickness of the pore sealing layer is formed on the surface and provides a sealed dielectric constant layer.

2. The method of claim 1 wherein the thickness of the pore sealing layer is greater than 0 and 5 nanometers or less.

3. The method of claim 1 wherein the thickness of the pore sealing layer is greater than 0 and 3 nanometers or less.

4. The method of claim 1 wherein the thickness of the pore sealing layer is greater than 0 and 1 nanometers or less.

5. The method of claim 1 wherein the porous low dielectric constant layer has a first dielectric constant and the sealed low dielectric constant layer has a second dielectric constant and a difference between the first dielectric constant and the second dielectric constant is greater than 0 and 0.5 or less.

6. The method of claim 5 wherein the difference between the first dielectric constant and the second dielectric constant is greater than 0 and 0.4 or less.

7. The method of claim 5 wherein the difference between the first dielectric constant and the second dielectric constant is greater than 0 and 0.2 or less.

8. The method of claim 1 wherein the porous low dielectric constant layer further comprises metal and wherein a first deposition rate of the pore sealing layer on the porous low dielectric film and a second deposition rate of the pore sealing layer on the metal is from 2 times greater to 10 times greater.

9. A method of forming a pore sealing layer via plasma enhanced atomic layer deposition process (PEALD), plasma enhanced cyclic chemical vapor deposition (PECCVD) or plasma enhanced ALD-like process, the method comprising the steps of:

a. providing a substrate having a porous low dielectric constant layer in a reactor;

b. contacting the substrate with at least one organosilicon compound selected from the group consisting of 1-methyl-1-methoxy-1-silacyclopentane, 1-methyl-1-ethoxy-1-silacyclopentane, 1-methyl-1-iso-propoxy-1-silacyclopentane, 1-methyl-1-n-propoxy-1-silacyclopentane, 1-methyl-1-n-butoxy-1-silacyclopentane, 1-methyl-1-sec-butoxy-1-silacyclopentane, 1-methyl-1-iso-butoxy-1-silacyclopentane, 1-methyl-1-tert-butoxy-1-silacyclopentane, 1-methoxy-1-silacyclopentane, 1-ethoxy-1-silacyclopentane, 1-methyl-1-methoxy-1-silacyclobutane, 1-methyl-1-ethoxy-1-silacyclobutane, 1-methoxy-1-

silacyclobutane, 1-ethoxy-1-silacyclobutane, 1,2-bis(dimethoymethylsilyl)methane, 1,2-bis(diethoymethylsilyl)methane, 1,2-bis(dimethoymethylsilyl)ethane, and 1,2-bis(diethoymethylsilyl)ethane, to provide an absorbed organosilicon compound on at least a portion of a surface of the porous low dielectric constant layer;

c. purging the reactor with a purge gas;

d. introducing a plasma into the reactor to react with absorbed organosilicon compound, wherein the plasma is at least one selected from nitrogen (N_2), argon (Ar), helium (He), hydrogen (H), and ammonia (NH_3), and

e. purging the reactor with a purge gas;

f. introducing into the reactor at least one organosilicon compound selected from the group consisting of 1-methyl-1-methoxy-1-silacyclopentane, 1-methyl-1-ethoxy-1-silacyclopentane, 1-methyl-1-iso-propoxy-1-silacyclopentane, 1-methyl-1-n-propoxy-1-silacyclopentane, 1-methyl-1-n-butoxy-1-silacyclopentane, 1-methyl-1-sec-butoxy-1-silacyclopentane, 1-methyl-1-iso-butoxy-1-silacyclopentane, 1-methyl-1-tert-butoxy-1-silacyclopentane, 1-methoxy-1-silacyclopentane, 1-ethoxy-1-silacyclopentane, 1-methyl-1-methoxy-1-silacyclobutane, 1-methyl-1-ethoxy-1-silacyclobutane, 1-methoxy-1-silacyclobutane, 1-ethoxy-1-silacyclobutane, 1,2-bis(dimethoymethylsilyl)methane, 1,2-bis(diethoymethylsilyl)methane, 1,2-bis(dimethoymethylsilyl)ethane, and 1,2-bis(diethoymethylsilyl)ethane, wherein the at least one organosilicon compound which differs from the at least one organosilicon compound in method step b);

g. purging the reactor with a purge gas;

h. introducing a plasma into the reactor to react with absorbed organosilicon compound, wherein the plasma is at least one selected from nitrogen (N_2), argon (Ar), helium (He), hydrogen (H), and ammonia (NH_3);

i. purging the reactor with a purge gas, wherein steps b through i are repeated until a desired thickness of the film is obtained.

10. The method of Claim 9, wherein step b to e are repeated for a certain number of cycles before step f.