

What is claimed is:

Claims

1. A method of forming a low-k flowable dielectric film over a trench formed on a surface of a patterned substrate, comprising:

delivering a silicon and carbon containing precursor at a first flow rate ~~into~~onto a surface of a patterned substrate disposed in a substrate processing region of a first substrate processing chamber for a first period of time and a second period of time;

flowing an oxygen-containing precursor into a remote plasma region of a plasma source while igniting a remote plasma to form a radical-oxygen precursor;

flowing the radical-oxygen precursor into the substrate processing region at a second flow rate after the first period of time has elapsed and during the second period of time; ~~and~~

transferring the patterned substrate from the first substrate processing chamber to a second substrate processing chamber after the second period of time has elapsed; and

exposing the silicon and carbon containing precursor to electromagnetic radiation in the second substrate processing chamber for a third period of time after the second period of time has elapsed, ~~wherein the electromagnetic radiation is provided at a first wavelength and at~~ to form a first power low-k flowable dielectric film over a trench formed on the surface of the patterned substrate

~~2. The method of claim 1,~~ wherein

the silicon and carbon containing precursor comprises octamethylcyclotetrasiloxane (OMCTS) tetramethylcyclotetrasiloxane (TMCTS), hexamethyldisiloxane (HMDSO), tetramethyldisiloxane (TMDSO), dimethyldisiloxane (DMDSO) or dimethyldichlorosilane (SiR_2Cl_2), ~~and~~

the electromagnetic radiation is provided at a first wavelength and at a first power,
the substrate processing region of the second substrate processing chamber is maintained at a pressure between 1 Torr and 600 Torr during the third period of time, and

the patterned substrate is maintained at a temperature of between 150°C and 500°C during the third period of time.

2. The method of claim 1, wherein the silicon and carbon containing precursor has a Si-O:Si ratio of less than 3.

3. The method of claim 1, wherein the radical-oxygen precursor comprises O₂, H₂O, O₃, H₂O₂, N₂O, NO or NO₂.

34. The method of claim 1, wherein flowing the radical-oxygen precursor into the substrate processing region during the second period of time further comprises:

controlling the pressure in the substrate processing region of the first substrate processing chamber to a pressure between 0.5 Torr and 3.0 Torr; and

controlling the temperature of the patterned substrate to a temperature of between 40°C and 150°C.

~~4. The method of claim 1, further comprising:~~

~~transferring the patterned substrate from the first substrate processing chamber to a second substrate processing chamber after the second period of time has elapsed, wherein~~

~~the method of exposing the silicon and carbon containing precursor to electromagnetic radiation for the third period of time is performed in the second substrate processing chamber,~~

~~the substrate processing region of the second substrate processing chamber is maintained at a pressure between 1 Torr and 600 Torr during the third period of time, and~~

~~the patterned substrate is maintained at a temperature of between 150°C and 500°C during the third period of time.~~

5. The method of claim 1, wherein the patterned substrate comprises a metal selected from a group consisting of titanium (Ti), tantalum (Ta), tungsten (W), cobalt (Co), copper (Cu) and aluminum (Al).

6. The method of claim 1, wherein the patterned substrate comprises a material selected from a group consisting of BCTe, GeSiAsTe, GeAsSe, and SeAsGeSi.

7. The method of claim 1, wherein at least a portion of the patterned substrate comprises a material that comprises germanium, antimony and tellurium.

8. The method of claim 1, wherein
the first flow rate is between 0.25 grams per minute (g/min) and 3 grams per minute (g/min) and the first period of time is between 1 seconds and 600 seconds,

the second flow rate is between 100 sccm and 2000 sccm and the second period of time is between 1 second and 1800 seconds, and

the first wavelength is between 240 nm and 600 nm, and the third period of time is between 10 seconds and 30 minutes.

9. A method of forming a low-k flowable dielectric film over a trench formed on a surface of a patterned substrate, comprising:

delivering a silicon and carbon containing precursor at a first flow rate ~~into~~onto a surface of a patterned substrate disposed in a substrate processing region of a first substrate processing chamber for a first period of time and a second period of time;

flowing an oxygen-containing precursor into a remote plasma region of a plasma source while igniting a remote plasma to form a radical-oxygen precursor;

flowing the radical-oxygen precursor into the substrate processing region at a second flow rate after the first period of time has elapsed and during the second period of time; and

transferring the patterned substrate from the first substrate processing chamber to a second substrate processing chamber after the second period of time has elapsed; and exposing the silicon and carbon containing precursor to electromagnetic radiation in the second substrate processing chamber for a third period of time after the second period of time has elapsed~~while, to form a low-k flowable dielectric film over a trench formed on the surface of the patterned substrate is maintained at a temperature of between 40°C and 500°C, wherein~~

the electromagnetic radiation is provided at a first wavelength and at a first power,
the substrate processing region of the second substrate processing chamber is maintained at a pressure between 1 Torr and 600 Torr during the third period of time, and the patterned substrate is maintained at a temperature of between 150°C and 500°C during the third period of time.

10. The method of claim 9, wherein the silicon and carbon containing precursor has a Si-O:Si ratio of less than 3.

11. The method of claim 9, the silicon and carbon containing precursor comprises octamethylcyclotetrasiloxane (OMCTS) tetramethylcyclotetrasiloxane (TMCTS), hexamethyldisiloxane (HMDSO), tetramethyldisiloxane (TMDSO), dimethyldisiloxane (DMDSO) or dimethyldichlorosilane (SiR₂Cl₂), and

12. The method of claim 9, wherein the radical-oxygen precursor comprises O₂, H₂O, O₃, H₂O₂, N₂O, NO or NO₂.

13. The method of claim 9, wherein flowing the radical-oxygen precursor into the substrate processing region during the second period of time further comprises:

controlling the pressure in the substrate processing region of the first substrate processing chamber to a pressure between 0.5 Torr and 3.0 Torr; and

controlling the temperature of the patterned substrate to a temperature of between 40°C and 150°C.

~~12. The method of claim 9, further comprising:~~

~~transferring the patterned substrate from the first substrate processing chamber to a second substrate processing chamber after the second period of time has elapsed, wherein~~

~~the method of exposing the silicon and carbon containing precursor to electromagnetic radiation for the third period of time is performed in the second substrate processing chamber,~~

~~14the substrate processing region of the second substrate processing chamber is maintained at a pressure between 1 Torr and 600 Torr during the third period of time, and~~

~~the patterned substrate is maintained at a temperature of between 150°C and 500°C during the third period of time.~~

43. The method of claim 9, wherein the patterned substrate comprises a metal selected from a group consisting of titanium (Ti), tantalum (Ta), tungsten (W), cobalt (Co), copper (Cu) and aluminum (Al).

4415. The method of claim 9, wherein the patterned substrate comprises a material selected from a group consisting of BCTe, GeSiAsTe, GeAsSe, and SeAsGeSi.

4516. The method of claim 9, wherein at least a portion of the patterned substrate comprises a material that comprises germanium, antimony and tellurium.

17. The method of claim 9, wherein

the first flow rate is between 0.25 grams per minute (g/min) and 3 grams per minute (g/min) and the first period of time is between 1 seconds and 600 seconds,

the second flow rate is between 100 sccm and 2000 sccm and the second period of time is between 1 second and 1800 seconds, and

the first wavelength is between 240 nm and 600 nm, and the third period of time is between 10 seconds and 30 minutes.