

CLAIMS

What is claimed is:

1. A method for depositing a film on a substrate, the method comprising:
 - arranging a substrate on a substrate support in a processing chamber;
 - setting a processing pressure in the processing chamber to a pressure within a predetermined pressure range;
 - setting a processing temperature of the processing chamber or the substrate support to a temperature within a predetermined temperature range;
 - supplying a process gas mixture to a gas distribution device, wherein the process gas mixture comprises a precursor gas, a gas including a first oxygen species, and an inert gas;
 - striking a plasma and depositing a film on the substrate in a predetermined film thickness range;
 - performing, within the processing chamber, *in-situ* annealing operations on the deposited film, the in-situ annealing operations including, at least:
 - setting a film annealing pressure in the processing chamber to a pressure within a predetermined annealing pressure range;
 - setting a film annealing temperature of the processing chamber or the substrate support to a temperature within a predetermined annealing temperature range;
 - supplying, for a predetermined annealing time period, a film annealing gas mixture for *in-situ* annealing of the deposited film, the annealing gas mixture comprising at least one of a second oxygen species or a hydrogen species; and
 - annealing the film on the substrate.
2. The method of claim 1, wherein the hydrogen species of the annealing gas mixture comprises hydrogen (H₂) introduced, at the processing chamber, at a flow rate in the range 500-10000 standard cubic centimeters per minute (sccm).

3. The method of claim 1, wherein the second oxygen species of the annealing gas mixture comprises O₂ introduced, at the processing chamber, at a flow rate in a range 500-10000 sccm.
4. The method of claim 1, further comprising:
 - supplying the precursor gas, the gas comprising the first oxygen species, and the inert gas to a mixing manifold to create the process gas mixture;
 - supplying at least one of the second oxygen species, or the hydrogen species, to the mixing manifold to create the annealing gas mixture; and
 - delivering the process gas mixture and annealing gas mixture to the gas distribution device arranged above the substrate support.
5. The method of claim 1, further comprising supplying a purge gas to the processing chamber.
6. The method of claim 5, wherein the purge gas includes argon.
7. The method of claim 1, wherein the predetermined annealing pressure range is 5-30T.
8. The method of claim 1, wherein the predetermined annealing temperature range is 500-700°C.
9. The method of claim 1, wherein the predetermined annealing time period is in a range 1-30 minutes.
10. The method of claim 1, wherein striking the plasma, at the processing chamber or at a multi-station tool, comprises supplying high-frequency (HF) power for one of an first electrode and a second electrode in a range from 1000 to 6500W and low-frequency (LF) power for one of the first electrode and the second electrode in a range from 500 to 6500W.

11. The method of claim 10, wherein striking the plasma, at the processing chamber or at a multi-station tool, comprises supplying HF power for one of a first electrode and a second electrode in a range from 2000 to 3000W and LF power for one of the first electrode and the second electrode in a range from 1000 to 3000W.
12. The method of claim 1, wherein the gas including the first oxygen species includes molecular oxygen.
13. The method of claim 1, wherein the gas including the first oxygen species is supplied at a flow rate in a range from 15 slm to 30 slm (standard liters per minute).
14. The method of claim 1, wherein the gas including the first oxygen species is supplied at a flow rate in a range from 20 slm to 25 slm.
15. The method of claim 1, wherein the precursor gas is supplied at a flow rate in a range from 40 sccm to 70 sccm (standard cubic centimeters per minute).
16. A system for depositing a film on a substrate, the system comprising:
 - a processing chamber;
 - a substrate support for supporting a substrate in the processing chamber;
 - a pressurizer configurable to set a processing and annealing pressure in the processing chamber to a predetermined pressure range, the annealing pressure set for an *in-situ* annealing of the film;
 - a heater configurable to set a processing and annealing temperature of the processing chamber or the substrate support to a predetermined temperature, the annealing temperature set for the *in-situ* annealing of the film;

a gas distribution device configurable to receive a supply of a process gas mixture and a film annealing gas mixture, wherein the process gas mixture comprises a precursor gas, a gas comprising a first oxygen species, and an inert gas, and wherein the film annealing gas mixture comprises at least one of a second oxygen species or a hydrogen species;

an electrode for striking a plasma to deposit the film in a predetermined thickness range; and

the processing chamber configured to anneal the deposited film *in-situ* based on the annealing pressure and temperature.