CLAIMS

1. A substrate processing system, comprising:

a processing chamber, comprising a chamber lid assembly, one or more chamber sidewalls, and a chamber base that collectively define a processing volume;

a gas delivery system fluidly coupled to the processing chamber, the gas delivery system comprising a first radical generator and a second radical generator; and

a non-transitory computer readable medium having instructions stored thereon for performing a method of processing a plurality of substrates when executed by a processor, the method comprising:

(a) receiving a substrate into the processing volume;

(b) exposing the substrate to an activated treatment gas, the activated treatment gas comprising an effluent of a treatment plasma formed in the first radical generator;

(c) exposing the substrate to a first tungsten-containing precursor and a first reducing agent to deposit a tungsten gapfill material;

(d) transferring the substrate out of the processing volume;

(e) before or after (a), conditioning the first radical generator, comprising:

i. flowing a conditioning gas into the first radical generator, the conditioning gas comprising a halogen-based component; and

ii. igniting and maintaining a conditioning plasma of the conditioning gas for a first period of time; and

(f) repeating (a)-(e) when a number of sequentially processed substrates is less than or equal to a threshold value,

wherein the method further comprises:

after (a) and before (b), forming a first tungsten nucleation layer;

before (b), forming a conformal tungsten layer on the first tungsten nucleation layer; and

forming a second tungsten nucleation layer on the conformal tungsten layer;

wherein the substrate comprises a material layer having a plurality of openings formed therein; and

wherein exposing the substrate to the activated treatment gas differentially inhibits tungsten deposition on a field surface of the substrate relative to surfaces within the plurality of openings.

2. The processing system of claim 1, the method further comprising:

(g) exposing chamber surfaces in the processing volume to an activated cleaning gas when the number of sequentially processed substrates is greater than the threshold value, the activated cleaning gas comprising an effluent of a cleaning plasma formed in the second radical generator; and

(h) repeating (a)-(g).

3. The processing system of claim 2,

wherein the treatment plasma is formed of a halogen-free nitrogen-containing gas; and

wherein a weight ratio of halogen radicals generated during (e) to nitrogen radicals generated in the first radical generator during (b) is no more than 5:1.

4. The processing system of claim 2, wherein a flow rate of the halogen-based component into the first radical generator is less than 10 sccm.

5. The processing system of claim 1, wherein forming the first tungsten nucleation layer comprises repeating cycles of alternately exposing the substrate to the first or a second tungsten-containing precursor and to the first or a second reducing agent.

6. The processing system of claim 2, wherein the gas delivery system further comprises:

a first valve fluidly coupled between the first radical generator and the processing chamber; and

a second valve fluidly coupled between the second radical generator and the processing chamber, wherein

exposing the chamber surfaces to the activated cleaning gas comprises fluidly isolating the first radical generator from the effluent of the cleaning plasma by use of the first valve.

7. The processing system of claim 6, wherein exposing the substrate to the activated treatment gas comprises fluidly isolating the second radical generator from the effluent of the treatment plasma by use of the second valve.

8. A method of processing a substrate, comprising:

(a) receiving the substrate into a processing volume of a processing system, the processing system comprising:

a processing chamber comprising a chamber lid assembly, one or more chamber sidewalls, and a chamber base that collectively define the processing volume; and

a gas delivery system fluidly coupled to the processing chamber, the gas delivery system comprising a first radical generator and a second radical generator;

(b) exposing the substrate to an activated treatment gas, the activated treatment gas comprising an effluent of a treatment plasma formed in the first radical generator;

(c) exposing the substrate to a first tungsten-containing precursor and a first reducing agent;

(d) transferring the substrate out of the processing volume; and

(e) before or after (a), conditioning the first radical generator, comprising:

i. flowing a conditioning gas into the first radical generator, the conditioning gas comprising a halogen-based component; and

ii. igniting and maintaining a conditioning plasma of the conditioning gas for a first period of time; and

(f) repeating (a)-(e) when a number of sequentially processed substrates is less than or equal to a threshold value.

wherein the method further comprises:

after (a) and before (b), forming a first tungsten nucleation layer;

before (b), forming a conformal tungsten layer on the first tungsten nucleation layer; and

forming a second tungsten nucleation layer on the conformal tungsten layer;

wherein the substrate comprises a material layer having a plurality of openings formed therein; and

wherein exposing the substrate to the activated treatment gas differentially inhibits tungsten deposition on a field surface of the substrate relative to surfaces within the plurality of openings.

9. The method of claim 8, further comprising:

(g) exposing chamber surfaces in the processing volume to an activated cleaning gas when the number of sequentially processed substrates is greater than the threshold value, the activated cleaning gas comprising an effluent of a cleaning plasma formed in the second radical generator; and

(h) repeating (a)-(g).

10. The method of claim 9,

wherein the treatment plasma is formed of a halogen-free nitrogen-containing gas; and

wherein a weight ratio of halogen radicals generated during (e) to nitrogen radicals generated in the first radical generator during (b) is no more than 5:1.

11. The method of claim 9, wherein a flow rate of the halogen-based component into the first radical generator is less than 10 sccm.

12. The method of claim 9, wherein the gas delivery system further comprises:

a first valve fluidly coupled between the first radical generator and the processing chamber; and

a second valve fluidly coupled between the second radical generator and the processing chamber, wherein

exposing the chamber surfaces to the activated cleaning gas comprises fluidly isolating the first radical generator from the effluent of the cleaning plasma by use of the first valve, and

exposing the substrate to the activated treatment gas comprises fluidly isolating the second radical generator from the effluent of the treatment plasma by use of the second valve.

13. The method of claim 12,

wherein the lid assembly comprises a lid plate and a showerhead coupled to the lid plate; and

wherein the first and second radical generators are in fluid communication with the processing volume through a gas inlet formed through the lid plate.

14. The method of claim 13,

wherein the effluent of the treatment plasma travels a first distance from the first radical generator to the processing volume;

wherein the effluent of the cleaning plasma travels a second distance from the second radical generator to the processing volume; and

wherein the first distance is less than the second distance.