CLAIMS

1. A method of forming a layer stack of oxide/nitride (ON) layers, comprising:

transferring a substrate to a process chamber;

heating a pedestal retaining the substrate to a deposition temperature;

flowing a first silicon-containing gas at a first silicon-containing gas flow rate, an oxygen-containing gas at an oxygen-containing gas flow rate, and a first dilution gas at a first dilution gas flow rate into the process chamber;

symmetrically applying a first radio frequency (RF) power to the first silicon-containing gas, the oxygen-containing gas, and the first dilution gas to form a first material layer of silicon dioxide (SiO_2);

after forming the first material layer of SiO_2, discontinuing the flow of the first silicon-containing gas, and continuing the flow of the oxygen-containing gas and the flow of the first dilution gas while symmetrically applying the first RF power;

flowing a second silicon-containing gas at a second silicon-containing gas flow rate, a nitrogen-containing gas at a nitrogen-containing gas flow rate, and a second dilution gas at a second dilution gas flow rate into the process chamber;

symmetrically applying a second RF power to the second silicon-containing gas, the nitrogen-containing gas, and the second dilution gas to form a second material layer of silicon nitride (Si_3N_4);

after forming the second material layer of Si_3N_4, discontinuing the flow of the second silicon-containing gas, and continuing the flow of the nitrogen-containing gas and the flow of the second dilution gas while symmetrically applying the second RF power; and

repeating the flowing the first silicon-containing gas, the oxygen-containing gas, and the first dilution gas, the symmetrically applying the first RF power, the flowing the second silicon-containing gas, the nitrogen-containing gas, and the second dilution gas, and the symmetrically applying the second RF power until a desired number of material layer pairs of the first material layer and the second material layer make up a layer stack.

2. The method of claim 1, further comprising:

transferring the substrate from the process chamber to a Rapid Thermal Processing (RTP) chamber; and

annealing at an annealing temperature greater than about 800 °C.

3. The method of claim 1, wherein the deposition temperature is about 500 °C to about 650 °C.

4. The method of claim 1, wherein the first silicon-containing gas comprises at least one of silane (SiH_4), tetraethyl orthosilicate (TEOS), and disilane (Si_2H_6).

5. The method of claim 1, wherein the oxygen-containing gas comprises at least one of nitrous oxide (N_2O), oxygen gas (O_2), and trioxygen (O_3).

6. The method of claim 1, wherein the first dilution gas comprises at least one of nitrogen gas (N_2), argon (Ar), and helium (He).

7. The method of claim 1, wherein the second silicon-containing gas comprises at least one of SiH_4 and Si_2H_6, the nitrogen-containing gas comprises at least one of ammonia (NH_3) and N_2, and the second dilution gas comprises at least one of N_2, Ar, and He.

8. The method of claim 1, wherein the first silicon-containing gas flow rate is about 600 standard cubic centimeters per minute (sccm) to about 5000 sccm, the oxygen-containing gas flow rate is about 500 sccm to about 15000 sccm, and the first dilution gas flow rate is about 100 sccm to about 20000 sccm.

9. The method of claim 1, wherein the second silicon-containing gas flow rate is about 30 sccm to about 300 sccm, the nitrogen-containing gas flow rate is about 2000 sccm to about 7000 sccm, and the second dilution gas flow rate is about 500 sccm to about 3000 sccm.

10. A method of forming a layer stack of oxide/nitride (ON) layers, comprising:

transferring a substrate to a first process chamber;

heating a first pedestal of the first process chamber retaining the substrate to a deposition temperature;

flowing a first silicon-containing gas at a first silicon-containing gas flow rate, an oxygen-containing gas at an oxygen-containing gas flow rate, and a first dilution gas at a first dilution gas flow rate into the first process chamber;

symmetrically applying a first radio frequency (RF) power to the first silicon-containing gas, the oxygen-containing gas, and the first dilution gas to form a first material layer of silicon dioxide (SiO_2);

after forming the first material layer of SiO_2, discontinuing the flow of the first silicon-containing gas, and continuing the flow of the oxygen-containing gas and the flow of the first dilution gas while symmetrically applying the first RF power;

flowing a second silicon-containing gas at a second silicon-containing gas flow rate, a nitrogen-containing gas at a nitrogen-containing gas flow rate, and a second dilution gas at a second dilution gas flow rate into the first process chamber;

symmetrically applying a second RF power to the second silicon-containing gas, the nitrogen-containing gas, and the second dilution gas to form a second material layer of silicon nitride (Si_3N_4);

after forming the second material layer of Si_3N_4, discontinuing the flow of the second silicon-containing gas, and continuing the flow of the nitrogen-containing gas and the flow of the second dilution gas while symmetrically applying the second RF power;

repeating the flowing the first silicon-containing gas, the oxygen-containing gas, and the first dilution gas, the symmetrically applying the first RF power, the flowing the second silicon-containing gas, the nitrogen-containing gas, and the second dilution gas, and the symmetrically applying the second RF power until a first portion of a desired number of material layer pairs of the first material layer and the second material layer make up a layer stack;

transferring the substrate from the first process chamber to a second process chamber;

heating a second pedestal of the second process chamber retaining the substrate to the deposition temperature; and

repeating the flowing the first silicon-containing gas, the oxygen-containing gas, and the first dilution gas, the symmetrically applying the first RF power, the flowing the second silicon-containing gas, the nitrogen-containing gas, and the second dilution gas, and the symmetrically applying the second RF power until a second portion of the desired number of the material layer pairs of the first material layer and the second material layer make up the layer stack.

11. The method of claim 10, further comprising:

transferring the substrate from the second process chamber to a Rapid Thermal Processing (RTP) chamber; and

annealing at an annealing temperature greater than about 800 °C.

12. The method of claim 10, wherein the deposition temperature is about 500 °C to about 650 °C.

13. The method of claim 10, wherein the first silicon-containing gas comprises at least one of silane (SiH_4), tetraethyl orthosilicate (TEOS), and disilane (Si_2H_6).

14. The method of claim 10, wherein the oxygen-containing gas comprises at least one of nitrous oxide (N_2O), oxygen gas (O_2), and trioxygen (O_3).

15. The method of claim 10, wherein the first dilution gas comprises at least one of nitrogen gas (N_2), argon (Ar), and helium (He).

16. The method of claim 10, wherein the second silicon-containing gas comprises at least one of SiH_4 and Si_2H_6, the nitrogen-containing gas comprises at least one of ammonia (NH_3) and N_2, and the second dilution gas comprises at least one of N_2, Ar, and He.

17. The method of claim 10, wherein the first silicon-containing gas flow rate is about 600 standard cubic centimeters per minute (sccm) to about 5000 sccm, the oxygen-containing gas flow rate is about 500 sccm to about 15000 sccm, and the first dilution gas flow rate is about 100 sccm to about 20000 sccm.

18. The method of claim 10, wherein the second silicon-containing gas flow rate is about 30 sccm to about 300 sccm, the nitrogen-containing gas flow rate is about 200 sccm to about 7000 sccm, and the second dilution gas flow rate is about 500 sccm to about 3000 sccm.

19. The method of claim 10, wherein the second dilution gas is N_2 and the second dilution gas flow rate is greater than about 2000 sccm.

20. The method of claim 1, wherein an impedance on a tuning electrode of the pedestal is modulated after forming the first material layer of SiO_2 during the flow of the oxygen-containing gas and the flow of the first dilution gas with the flow of the first silicon-containing gas discontinued.