WHAT IS CLAIMED IS:

1. A method of etching a silicon-containing layer on a surface of a substrate in a substrate processing region of a substrate processing chamber, wherein the method leaves a relatively smooth post-etch surface, the method comprising:

flowing a fluorine-containing precursor and a hydrogen-containing precursor into a first remote plasma region fluidly coupled to the substrate processing region while forming a plasma in the first plasma region to produce plasma effluents, wherein a flow rate of the fluorine-containing precursor and a flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of less than 1:1 or greater than 5:1;

etching the silicon-containing layer by flowing the plasma effluents into the substrate processing region while forming solid by-products on the surface of the substrate; and

sublimating the solid by-products to leave the relatively smooth post-etch surface by increasing a temperature of the substrate above a sublimation temperature of the solid by-products.

2. The method of claim 1 wherein the fluorine-containing precursor comprises at least one precursor selected from the group consisting of nitrogen trifluoride, hydrogen fluoride, diatomic fluorine, monatomic fluorine and fluorine-substituted hydrocarbons.

3. The method of claim 1 wherein the hydrogen-containing precursor comprises at least one precursor selected from the group consisting of atomic hydrogen, molecular hydrogen, ammonia, a hydrocarbon and an incompletely halogen-substituted hydrocarbon.

4. The method of claim 1 wherein the silicon-containing layer is maintained above or about 50°C during the etching operation.

5. The method of claim 1 wherein the operations of etching the silicon-containing layer and sublimating the solid by-products comprise a step and an integral number of steps are used to reduce the amount of material removed during each cycle.

6. The method of claim 5 wherein a total thickness of the silicon-containing layer is removed in three steps and each step removes 20% to 40% of the total thickness.

7. The method of claim 5 each step removes about 150 Å or less from the silicon-containing layer.

8. The method of claim 1 wherein the flow rate of the fluorine-containing precursor and the flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of less than 1:2.

9. The method of claim 1 wherein the flow rate of the fluorine-containing precursor and the flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of greater than 10:1.

10. The method of claim 1 wherein the silicon-containing layer comprises silicon oxide.

11. The method of claim 1 wherein the method reduces a difference in etch-rate between a densely patterned area and a sparsely patterned area.

12. A method of etching a silicon-containing layer on a surface of a substrate in a substrate processing region of a substrate processing chamber, the method comprising:

flowing a fluorine-containing precursor and a hydrogen-containing precursor into a first remote plasma region fluidly coupled to the substrate processing region while forming a train of plasma pulses in the first plasma region to produce plasma effluents;

etching the silicon-containing layer by flowing the plasma effluents into the substrate processing region while forming solid by-products on the surface of the substrate; and

sublimating the solid by-products by increasing a temperature of the substrate above a sublimation temperature of the solid by-products.

13. The method of claim 12 wherein the train of plasma pulses are created by pulsing the plasma power applied to the first plasma region, and a flow of the hydrogen-

containing precursor and a flow of the fluorine-containing precursor are both constant during the etching operation.

14. The method of claim 12 wherein the train of plasma pulses are created by pulsing the flow of at least one of a flow of the fluorine-containing precursor and a flow of the hydrogen-containing precursor.

15. The method of claim 12 wherein a repetition frequency of the train of plasma pulses is between about 0.1 Hz and about 1.0 Hz.

What is claimed is:

1. A method of etching a silicon-containing layer on a surface of a substrate in a substrate processing region of a substrate processing chamber, wherein the method leaves a relatively smooth post-etch surface, the method comprising:

flowing a fluorine-containing precursor and a hydrogen-containing precursor into a first remote plasma region fluidly coupled to the substrate processing region while forming a plasma in the first plasma region to produce plasma effluents, wherein a flow rate of the fluorine-containing precursor and a flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of less than 1:2;

etching the silicon-containing layer by flowing the plasma effluents into the substrate processing region while forming solid by-products on the surface of the substrate; and

sublimating the solid by-products to leave the relatively smooth post-etch surface by increasing a temperature of the substrate above a sublimation temperature of the solid by-products.

2. The method of claim **1** wherein the fluorine-containing precursor comprises at least one precursor selected from the group consisting of nitrogen trifluoride, hydrogen fluoride, diatomic fluorine, monatomic fluorine and fluorine-substituted hydrocarbons.

3. The method of claim **1** wherein the hydrogen-containing precursor comprises at least one precursor selected from the group consisting of atomic hydrogen, molecular hydrogen, ammonia, a hydrocarbon and an incompletely halogen-substituted hydrocarbon.

4. The method of claim **1** wherein the silicon-containing layer is maintained above or about 50° C. during the etching operation.

5. The method of claim **1** wherein the operations of etching the silicon-containing layer and sublimating the solid by-products comprise a step and an integral number of steps are used to reduce the amount of material removed during each cycle.

6. The method of claim **5** wherein a total thickness of the silicon-containing layer is removed in three steps and each step removes 20% to 40% of the total thickness.

7. The method of claim **5** each step removes about 150 Å or less from the silicon-containing layer.

8. The method of claim **1** wherein the silicon-containing layer comprises silicon oxide.

9. A method of etching a silicon-containing layer on a surface of a substrate in a substrate processing region of a substrate processing chamber, wherein the method reduces a difference in etch-rate between a densely patterned area and a sparsely patterned area, the method comprising:

flowing a fluorine-containing precursor and a hydrogen-containing precursor into a first remote plasma region fluidly coupled to the substrate processing region while forming a plasma in the first plasma region to produce plasma effluents, wherein a flow rate of the fluorine-

containing precursor and a flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of less than 1:2;

etching the silicon-containing layer in the densely patterned area and the sparsely patterned area by flowing the plasma effluents into the substrate processing region while forming solid by-products on the surface of the substrate; and

sublimating the solid by-products by increasing a temperature of the substrate above a sublimation temperature of the solid by-products.

10. The method of claim **9** wherein the fluorine-containing precursor comprises at least one precursor selected from the group consisting of nitrogen trifluoride, hydrogen fluoride, diatomic fluorine, monatomic fluorine and fluorine-substituted hydrocarbons.

11. The method of claim **9** wherein the hydrogen-containing precursor comprises at least one precursor selected from the group consisting of atomic hydrogen, molecular hydrogen, ammonia, a hydrocarbon and an incompletely halogen-substituted hydrocarbon.

12. The method of claim **9** wherein the operations of etching the silicon-containing layer and sublimating the solid by-products comprise a step and an integral number of steps are used to reduce the amount of material removed during each cycle.

13. The method of claim **12** wherein a total thickness is removed from the silicon-containing layer in three steps and each step removes 20% to 40% of the total thickness.

14. The method of claim **12** wherein each step removes about 100 Å or less from the silicon-containing layer.

15. The method of claim **9** wherein the flow rate of the fluorine-containing precursor and the flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of less than 1:4.

16. The method of claim **9** wherein the silicon-containing layer comprises silicon oxide.

17. A method of etching a silicon-containing layer on a surface of a substrate in a substrate processing region of a substrate processing chamber, the method comprising:

flowing a fluorine-containing precursor and a hydrogen-containing precursor into a first remote plasma region fluidly coupled to the substrate processing region while forming a train of plasma pulses in the first plasma region to produce plasma effluents, wherein a flow rate of the fluorine-containing precursor and a flow rate of the hydrogen-containing precursor result in a hydrogen-to-fluorine atomic flow ratio of less than 1:2;

etching the silicon-containing layer by flowing the plasma effluents into the substrate processing region while forming solid by-products on the surface of the substrate; and

sublimating the solid by-products by increasing a temperature of the substrate above a sublimation temperature of the solid by-products.

18. The method of claim **17** wherein the train of plasma pulses are created by pulsing the plasma power applied to the first plasma region.

19. The method of claim **18** wherein a flow of the hydrogen-containing precursor and a flow of the fluorine-containing precursor are both constant during the etching operation.

20. The method of claim **17** wherein the train of plasma pulses are created by pulsing the flow of at least one of a flow of the fluorine-containing precursor and a flow of the hydrogen-containing precursor.

21. The method of claim **17** wherein the operation of sublimating the solid by-products comprises multiple substrate anneals which occur following each of the plasma pulses.

22. The method of claim **17** wherein a repetition frequency of the train of plasma pulses is between about 0.1 Hz and about 1.0 Hz.

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