CLAIMS

1. An etching method comprising:

flowing an oxygen-containing precursor into a processing region of a semiconductor processing chamber;

contacting a substrate housed in the processing region with the oxygen-containing precursor, wherein the substrate comprises an exposed region of ruthenium, and wherein the contacting produces ruthenium tetroxide;

vaporizing the ruthenium tetroxide from a surface of the exposed region of ruthenium, wherein an amount of oxidized ruthenium remains;

contacting the amount of oxidized ruthenium with a hydrogen-containing precursor; and

removing the amount of oxidized ruthenium,

wherein the etching method is performed while maintaining a plasma-free environment in the processing region; and

wherein a temperature within the processing region is maintained at less than or equal to 10 °C.

2. The etching method of claim 1, wherein the temperature within the processing region is maintained at less than or equal to 0 °C.

3. The etching method of claim 1, wherein the hydrogen-containing precursor comprises diatomic hydrogen.

4. The etching method of claim 1, further comprising an additional operation of:

contacting the substrate with the hydrogen-containing precursor prior to flowing the oxygen-containing precursor, wherein the hydrogen-containing precursor exposes the exposed region of ruthenium.

5. The etching method of claim 1, wherein removing the amount of oxidized ruthenium exposes additional ruthenium, and wherein the method is repeated for an additional cycle.

6. The etching method of claim 1, wherein removal of the amount of oxidized ruthenium is selective with respect to an exposed region of silicon oxide, titanium oxide, or tungsten oxide.

7. The etching method of claim 1, wherein a pressure within the semiconductor processing chamber is maintained at greater than or equal to 1 Torr.

8. The etching method of claim 1, wherein the oxygen-containing precursor comprises diatomic oxygen, ozone, water, an alcohol, hydrogen peroxide, or nitrous oxide.

9. An etching method comprising:

flowing an oxygen-containing precursor into a processing region of a semiconductor processing chamber;

contacting a substrate housed in the processing region with the oxygen-containing precursor, wherein the substrate comprises an exposed region of ruthenium, and wherein the contacting produces ruthenium tetroxide;

performing a particle treatment with an inert precursor within the processing region of the semiconductor processing chamber, wherein the inert precursor comprises argon or helium;

contacting the ruthenium tetroxide with the inert precursor; and

removing the ruthenium tetroxide,

wherein the etching method is performed while maintaining a plasma-free environment in the processing region; and

wherein a temperature within the processing region is maintained at less than or equal to 10 °C.

10. The etching method of claim 9, wherein the temperature within the processing region is maintained at less than or equal to 0 °C.

11. The etching method of claim 9, wherein removing the ruthenium tetroxide exposes additional ruthenium, and wherein the method is repeated for an additional cycle.

12. The etching method of claim 9, further comprising an additional operation of:

contacting the substrate with a hydrogen-containing precursor prior to flowing the oxygen-containing precursor, wherein the hydrogen-containing precursor exposes the exposed region of ruthenium.

13. The etching method of claim 9, wherein the oxygen-containing precursor comprises diatomic oxygen, ozone, water, an alcohol, hydrogen peroxide, or nitrous oxide.

14. An etching method comprising:

contacting a substrate disposed within a processing region of a semiconductor processing chamber with a hydrogen-containing precursor, wherein the contacting exposes ruthenium metal on the substrate;

flowing an oxygen-containing precursor into the processing region of the semiconductor processing chamber;

contacting the ruthenium metal exposed on the substrate with the oxygen-containing precursor, wherein the contacting produces ruthenium tetroxide; and

vaporizing the ruthenium tetroxide from a surface of the ruthenium metal,

wherein the etching method is performed while maintaining a plasma-free environment in the processing region; and

wherein a temperature within the processing region is maintained at less than or equal to 10 °C.

15. The etching method of claim 14, wherein the temperature within the processing region is maintained at less than or equal to 0 °C.

16. The etching method of claim 14, further comprising:

repeating the method for at least one additional cycle.

17. The etching method of claim 14, wherein the oxygen-containing precursor comprises diatomic oxygen, ozone, water, an alcohol, hydrogen peroxide, or nitrous oxide.