Claims

What is claimed is

1. A process for etching a metal-containing material from a surface of a substrate, the steps comprising:

a Volatilization Step comprising:

(i) exposing the metal-containing material to one or more volatilizing agents comprising one or more halogen-free organic acids selected from the group of propionic acid, isobutyric acid, pivalic acid, acetic acid, butanoic acid, acrylic acid, methacrylic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 3-butenoic acid, cyclopropanecarboxylic acid, pentanoic acid, (2*E*)-but-2-enoic acid and (*Z*)-2-butenoic acid to produce a volatile byproduct from the metal-containing material,

(ii) a purge; and

optionally a Surface Modification Step comprising:

(a) exposing the metal-containing material to one or more surface modification agents comprises one or more chlorinating agent to form a metal-containing material that is different than the metal-containing material prior to exposure to the one or more surface modification agents; and

(b) a purge.

2. The process of claim 1 comprising the Volatilization Step and the Surface Modification Step.

3. The process of claim 1 comprising the Volatilization Step and the Surface Modification Step, wherein the Volatilization Step precedes the Surface Modification Step.

4. The process of claim 1 comprising the Volatilization Step and the Surface Modification Step, wherein the Surface Modification Step precedes the Volatilization Step.

5. The process of claim 1, wherein the metal comprises one or more of Co, Ni, Cu, Mo, Ru, W, TiN and TaN.

6. The process of claim 1, wherein in step (a) the one or more chlorinating agent is selected from the group of $SOCl_2$, Cl_2, BCI_3, HCl and $TiCl_4$.

7. The process of claim 1, wherein in step (a) the one or more chlorinating agent comprises $SOCl_2$.

8. The process of claim 1, wherein in step (a) the one or more surface modification agents is dosed as a plasma or a component of a plasma.

9. The process of claim 1, wherein in step (a) exposure time of the one or more surface modification agents is from about 0.5 seconds to about 30 seconds.

10. The process of claim 1, wherein in step (a) one or more surface modification agents is flowed at from about 100 sccm to about 5000 sccm.

11. The process of claim 1, wherein the step (a) is carried out at a pressure from about 0.5 torr to about 100 torr.

12. The process of claim 1, wherein in step (i) the one or more one or more volatilizing agents comprises one or more halogen-free organic acids selected from the group of propionic acid, isobutyric acid, pivalic acid and combinations thereof.

13. The process of claim 1, wherein in step (i) exposure time of the one or more volatilizing agents is from about 0.5 seconds to about 30 seconds.

14. The process of claim 1, wherein in step (i) one or more volatilizing agents is flowed at from about 1 sccm to about 500 sccm.

15. The process of claim 1, wherein the step (i) is carried out at a pressure from about 0.05 torr to about 10 torr.

16. The process of any of claims 1-4, wherein the process comprises about 5 to about 1000 cycles.