CLAIMS

1. An etching composition, comprising:

1) at least one oxidizing agent;

2) at least one unsaturated carboxylic acid, the at least one unsaturated carboxylic acid comprising crotonic acid, propenoic acid, 3-pentenoic acid, 5-hexenoic acid, 6-heptenoic acid, 7-octenoic acid, 8-nonenoic acid, or 9-undecylenic acid;

3) at least one metal corrosion inhibitor; and

4) water;

wherein the composition is free of a fluoride containing compound.

2. The composition of claim 1 or claim 2, wherein the composition has a pH between 0 and 7.

3. The composition of claim 1 or claim 2, wherein the at least one oxidizing agent comprises hydrogen peroxide.

4. The composition of any one of claims 1 to 3, wherein the at least one oxidizing agent is in the amount of from 0.5% to 20% by weight of the composition.

5. The composition of any one of claims 1 to 4, wherein the at least one unsaturated carboxylic acid comprises a carboxylic acid having three to ten carbon atoms.

6. The composition of any one of claims 1 to 5, wherein the at least one unsaturated carboxylic acid comprises crotonic acid.

7. The composition of any one of claims 1 to 6, wherein the at least one unsaturated carboxylic acid is in the amount of from 0.005% to 3% by weight of the composition.

8. The composition of any one of claims 1 to 7, wherein the at least one metal corrosion inhibitor comprises a substituted or unsubstituted azole.

9. The composition of claim 8, wherein the azole is a triazole, an imidazole, or a tetrazole.

10. The composition of any one of claims 1 to 9, wherein the at least one metal corrosion inhibitor comprises a benzotriazole optionally substituted by at least one substituent selected from the group consisting of alkyl groups, aryl groups, halogen groups, amino groups, nitro groups, alkoxy groups, and hydroxyl groups.

11. The composition of any one of claims 1 to 10, wherein the at least one metal corrosion inhibitor comprises a compound selected from the group consisting of benzotriazole, 5-aminobenzotriazole, 1-hydroxybenzotriazole, 5-phenylthiol-benzotriazole, 5-chlorobenzotriazole, 4-chlorobenzotriazole, 5-bromobenzotriazole, 4-bromobenzotriazole, 5-fluorobenzotriazole, 4-fluorobenzotriazole, naphthotriazole, tolyltriazole, 5-phenyl-benzotriazole, 5-nitrobenzotriazole, 4-nitrobenzotriazole, 3-amino-5-mercapto-1,2,4-triazole, 2-(5-amino-pentyl)-benzotriazole, 1-amino-benzotriazole, 5-methyl-1H-benzotriazole, benzotriazole-5-carboxylic acid, 4-methylbenzotriazole, 4-ethylbenzotriazole, 5-ethylbenzotriazole, 4-propylbenzotriazole, 5-propylbenzotriazole, 4-isopropylbenzotriazole, 5-isopropylbenzotriazole, 4-n-butylbenzotriazole, 5-n-butylbenzotriazole, 4-isobutylbenzotriazole, 5-isobutylbenzotriazole, 4-pentylbenzotriazole, 5-pentylbenzotriazole, 4-hexylbenzotriazole, 5-hexylbenzotriazole, 5-methoxybenzotriazole, 5-hydroxybenzotriazole, dihydroxypropylbenzotriazole, 1-[N,N-bis(2-ethylhexyl)aminomethyl]-benzotriazole, 5-t-butyl benzotriazole, 5-(1',1'-diimethylpropyl)-benzotriazole, 5-(1',1',3'-trimethylbutyl)benzotriazole, 5-n-octyl benzotriazole, and 5-(1',1',3',3'-tetramethylbutyl)benzotriazole.

12. The composition of any one of claims 1 to 11, wherein the at least one metal corrosion inhibitor is in the amount of from 0.005% to 3% by weight of the composition.

13. The composition of any one of claims 1 to 12, wherein the water is in the amount of from 60% to 98% by weight of the composition.

14. The composition of any one of claims 1 to 13, further comprising at least one pH adjusting agent.

15. The composition of claim 14, wherein the at least one pH adjusting agent comprises a base or an acid.

16. The composition of claim 15, wherein the base is free of a metal ion and is not a quaternary ammonium hydroxide or an alkyl hydroxide, and the acid is not a saturated carboxylic acid or a hydrogen halide.

17. The composition of any one of claims 1 to 16, further comprising an organic solvent selected from the group consisting of water soluble alcohols, water soluble ketones, water soluble esters, and water soluble ethers.

18. The composition of claim 17, wherein the organic solvent is in the amount of from 2% to 20% by weight of the composition.

19. A method, comprising:

contacting a semiconductor substrate containing a TiN feature with a composition of any one of claims 1 to 18 to remove the TiN feature.

20. The method of claim 19, further comprising rinsing the semiconductor substrate with a rinse solvent after the contacting step.

21. The method of claim 20, further comprising drying the semiconductor substrate after the rinsing step.

22. The method of any one of claims 19 to 21, wherein the method does not form a cobalt oxide hydroxide layer in the semiconductor substrate.

23. An article formed by the method of claim 19, wherein the article is a semiconductor device.

24. The article of claim 23, wherein the semiconductor device is an integrated circuit.

25. The composition of any one of claims 1 to 18, wherein

the at least one oxidizing agent is in the amount of from 0.5% to 20% by weight of the composition;

the at least one unsaturated carboxylic acid is in the amount of from 0.005% to 3% by weight of the composition;

the at least one metal corrosion inhibitor is in the amount of from 0.005% to 3% by weight of the composition; and

the water is in the amount of from 60% to 98% by weight of the composition.