CLAIMS

1. A cleaning composition, comprising:

1) at least one redox agent;

2) at least one water soluble organic solvent;

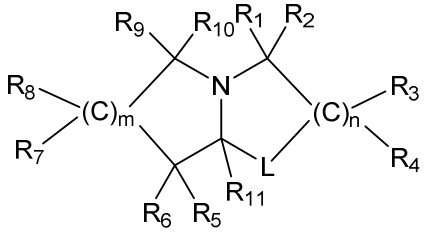
3) at least one metal-containing additive in an amount from about 0.001% by weight to about 0.5% by weight of the composition;

4) at least one cyclic amine; and

5) water.

2. The composition of claim 1, wherein the composition has a pH from about 7 to about 12.

3. The composition of claim 1, wherein the at least one cyclic amine comprises a cyclic amine of formula (I):



(I),

in which

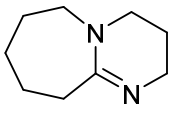
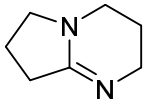
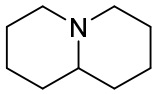
n is 1, 2, or 3;

m is 1, 2, or 3;

each of R_1-R_{10}, independently, is H, C_1-C_6 alkyl, or aryl; and

L is -O-, -S-, -N(R_a)-, or -C(R_aR_b)-, in which each of R_a and R_b, independently, is H, C_1-C_6 alkyl, or aryl; and

R_{11} is H or together with R_a forms a second bond between L and the C atom to which R_{11} is attached.

4. The composition of claim 3, wherein the cyclic amine of formula (I) is , , or .

5. The composition of claim 1, wherein the at least one cyclic amine is from about 0.1% by weight to about 2% by weight of the composition.

6. The composition of claim 1, wherein the at least one redox agent comprises hydroxylamine.

7. The composition of claim 1, wherein the at least one redox agent is from about 0.5% by weight to about 20% by weight of the composition.

8. The composition of claim 1, wherein the at least one water soluble organic solvent comprises two organic solvents.

9. The composition of claim 8, wherein the two organic solvents are each independently selected from the group consisting of alkylene glycols and alkylene glycol ethers.

10. The composition of claim 1, wherein the at least one water soluble organic solvent is from about 60% by weight to about 95% by weight of the composition.

11. The composition of claim 1, wherein the at least one metal-containing additive comprises a metal halide, a metal hydroxide, a metal boride, a metal alkoxide, a metal oxide, or a metal-containing ammonium salt.

12. The composition of claim 1, wherein the at least one metal-containing additive comprises a Group 2A metal, a Group 3B metal, a Group 4B metal, a Group 5B metal, or a lanthanide metal.

13. The composition of claim 12, wherein the at least one metal-containing additive comprises Ca, Ba, Ti, Hf, Sr, La, Ce, W, V, Nb, or Ta.

14. The composition of claim 1, wherein the at least one metal-containing additive comprises a tungsten boride, $Ca(OH)_2$, $BaCl_2$, $SrCl_2$, $LaCl_3$, $CeCl_3$, $(NH_4)_2TiF_6$, $BaTiO_3$, $Ti(OEt)_4$, $Ti(OCH(CH_3)_2)_4$, HfO_2, V_2O_5, Nb_2O_5, or TaF_3.

15. The composition of claim 1, wherein the at least one metal-containing additive is from about 0.001% by weight to about 0.4% by weight of the composition.

16. The composition of claim 1, wherein the water is from about 5% by weight to about 28% by weight of the composition.

17. The composition of claim 1, further comprising a pH adjusting agent, the pH adjusting agent being different from the at least one cyclic amine.

18. The composition of claim 1, further comprising at least one cleaning additive.

19. The composition of claim 18, wherein the at least one cleaning additive comprises a sulfur-containing additive.

20. The composition of claim 19, wherein the sulfur-containing additive comprises a thiol or a thioether.

21. A cleaning composition, comprising:

1) at least one redox agent;

2) at least one water soluble organic solvent;

3) at least one metal-containing additive;

4) at least one cyclic amine;

5) at least one sulfur-containing additive; and

6) water;

wherein the sulfur-containing additive comprises 3-amino-5-mercapto-1H-1,2,4-triazole, β-mercaptoethanol, 3-amino-5-methylthio-1H-1,2,4-triazole, 1-phenyl-1H-tetrazole-5-thiol, 4-methyl-4H-1,2,4-triazole-3-thiol, 2-pyridinethiol, or 3-mercapto-propionic acid.

22. The composition of claim 19, wherein the sulfur-containing additive is from about 0.01% by weight to about 0.15% by weight of the composition.

23. The composition of claim 18, wherein the at least one cleaning additive comprises an organic acid.

24. The composition of claim 23, wherein the organic acid comprises a carboxylic acid or a sulfonic acid.

25. The composition of claim 23, wherein the at least one organic acid is from about 0.1% by weight to about 0.5% by weight of the composition.

26. The composition of claim 18, wherein the at least one cleaning additive comprises an amino acid.

27. A cleaning composition, comprising:

1) at least one redox agent;

2) at least one water soluble organic solvent;

3) at least one metal-containing additive;

4) at least one cyclic amine;

5) at least one amino acid; and

6) water;

wherein the amino acid is glycine.

28. The composition of claim 26, wherein the amino acid is from about 0.01% by weight to about 0.15% by weight of the composition.

29. A method, comprising:

contacting a semiconductor substrate containing post etch residues or post ashing residues with a cleaning composition of claim 1.

30. The method of claim 29, wherein the semiconductor substrate further comprises a layer comprising a material selected from the group consisting of Cu, Co, W, AlOx, AlN, AlOxNy, Ti, TiN, Ta, TaN, TiOx, ZrOx, HfOx, and TaOx.

31. The method of claim 29, further comprising rinsing the semiconductor substrate with a rinse solvent after the contacting step.

32. The method of claim 31, further comprising drying the semiconductor substrate after the rinsing step.

33. The method of claim 29, further comprising forming a semiconductor device from the semiconductor substrate.