CLAIMS

1. An aqueous cleaning solution for removing metal contaminants from a dielectric structure with electrolessly deposited cobalt or cobalt alloy caps after electrolessly depositing the cobalt or cobalt alloy caps over metal lines in the dielectric structure, comprising:

a pH adjustor;

a complexing agent comprising phytic acid;

a corrosion inhibitor capable so as to protect electrolessly deposited cobalt or cobalt alloy caps on metal lines over the dielectric structure; and

one or more of:

a solubilizing agent,

a dielectric etchant, and

a surfactant; and

wherein the aqueous cleaning solution is capable so as to remove metal ions from the dielectric structure, wherein:

the pH adjustor has a concentration of less than 0.1 M and includes at least one of a sulphuric acid, sulfonic acid, methanesulfonic acid, benzene sulfonic acid, triflic acid, hypophosphorous acid, oxalic acid, halogenated carboxylic acids, trifluoroacetic acid, acetylenedicarboxylic acid, squaric acid, dihydroxyfumaric acid, maleic acid, or mixtures thereof;

the complexing agent has a concentration from 0.1 to 200 mM;

the corrosion inhibitor has a concentration from 0.1 to 50 mM and comprises at least one of a triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate, alkylphosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, or combinations thereof;

the solubilizing agent is present at a concentration less than 200 mL/L and comprises one or more of a primary alcohol, secondary alcohol, tertiary alcohol, polyol, ethylene glycol, propylene glycol, 2-n-butoxyethanol, dimethylsulfoxide, propylenecarbonate, or combinations thereof;

the dielectric etchant is present at a concentration from 1 to 100 mM and comprises one or more of a hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal alt of fluoride, tetrafluoroborate, hexafluorosilicate, or mixtures thereof;

the surfactant is present at a concentration of less than 2000 ppm and comprises at least one of anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, or combinations thereof; and

the aqueous cleaning solution has a pH less than or equal to 3.

2. An aqueous cleaning solution for removing metal contaminants from a dielectric structure with electrolessly deposited cobalt or cobalt alloy caps after electrolessly depositing the cobalt or cobalt alloy caps over metal lines in the dielectric structure, comprising:

a pH adjustor;

a complexing agent comprising phytic acid;

a corrosion inhibitor capable so as to protect electrolessly deposited cobalt or cobalt alloy caps on metal lines over the dielectric structure; and

one or more of:

a solubilizing agent, wherein the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, propylene glycol, 2-n-butoxyethanol, or isopropyl alcohol;

a dielectric etchant, and

a surfactant; and

wherein the aqueous cleaning solution is capable so as to remove metal ions from the dielectric structure.

3. An aqueous cleaning solution for removing metal contaminants from a dielectric structure with electrolessly deposited cobalt or cobalt alloy caps after electrolessly

depositing the cobalt or cobalt alloy caps over metal lines in the dielectric structure, comprising:

a pH adjustor comprising hypophosphorous acid, squaric acid, dihydroxyfumaric acid, or mixtures thereof;

a complexing agent comprising phytic acid;

a corrosion inhibitor capable so as to protect an electrolessly deposited cobalt or cobalt alloy caps on a metal lines over the dielectric structure; and

one or more of:

a solubilizing agent,

a dielectric etchant, and

a surfactant; and

wherein the aqueous cleaning solution is capable so as to remove metal ions from the dielectric structure.

4. The aqueous cleaning solution of claim 3, wherein:

the complexing agent further comprises at least one of carboxylic acids, hydroxycarboxylic acids, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, or mixtures thereof;

the corrosion inhibitor comprises at least one of a triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate, alkylphosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, or combinations thereof;

the solubilizing agent comprises one or more of a dimethylsulfoxide, ethylene glycol, propylene glycol, 2-n-butoxyethanol, or isopropyl alcohol;

the dielectric etchant comprises one or more of a hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal salts of fluoride, tetrafluoroborate, hexafluorosilicate, or mixtures thereof;

the surfactant comprises at least one of anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, or combinations thereof; and

the aqueous cleaning solution has a pH less than or equal to 3.

5. The aqueous cleaning solution of claim 3, wherein:

the pH adjustor has a concentration of less than 0.1 M;

the complexing agent has a concentration from 0.1 to 200 mM and further comprises at least one of a carboxylic acid, hydroxycarboxylic acid, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, or combinations thereof;

the corrosion inhibitor has a concentration from 0.1 to 50 mM and comprises at least one of a triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate, alkylphosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, or combinations thereof;

the solubilizing agent is present at a concentration less than 200 mL/L and comprises one or more of a primary alcohol, secondary alcohol, tertiary alcohol, polyol, ethylene glycol, propylene glycol, 2-n-butoxyethanol, dimethylsulfoxide, propylenecarbonate, or combinations thereof;

the dielectric etchant is present at a concentration from 1 to 100 mM and comprises one or more of a hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal salts of fluoride, tetrafluoroborate, hexafluorosilicate, or mixtures thereof;

the surfactant is present at a concentration of less than 2000 ppm and comprises at least one of anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, or combinations thereof; and

the aqueous cleaning solution has a pH less than or equal to 3.

6. The aqueous cleaning solution of claim 3, wherein:

the complexing agent further comprises at least one of carboxylic acids, hydroxycarboxylic acids, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, or mixtures thereof.

7. The aqueous cleaning solution of claim 3, wherein:

the corrosion inhibitor comprises at least one of a triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate, alkylphosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, or combinations thereof

8. The aqueous cleaning solution of claim 3, wherein:

the dielectric etchant comprises one or more of a hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal salts of fluoride, tetrafluoroborate, hexafluorosilicate, or mixtures thereof.

9. The aqueous cleaning solution of claim 3, wherein:

the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, propylene glycol, 2-n-butoxyethanol, or isopropyl alcohol.

10. The aqueous cleaning solution of claim 3, wherein:

the pH adjustor has a concentration of between 0 to 0.1 M;

the complexing agent has a concentration from 0.1 to 200 mM;

the corrosion inhibitor has a concentration from 0.1 to 50 mM;

the solubilizing agent has a concentration from 0 to 200 mL/L;

the dielectric etchant has a concentration from 1 to 100 mM;

the surfactant has a concentration from 0 to 2000 ppm; and the aqueous cleaning solution has a pH less than or equal to 3.

11. An aqueous cleaning solution for removing metal contaminants from a dielectric structure with electrolessly deposited cobalt or cobalt alloy caps after electrolessly depositing the cobalt or cobalt alloy caps over metal lines in the dielectric structure, comprising:

a pH adjustor;

a complexing agent comprising phytic acid;

a corrosion inhibitor capable so as to protect electrolessly deposited cobalt or cobalt alloy caps on metal lines over the dielectric structure; and

one or more of:

a solubilizing agent, wherein:

the pH adjustor has a concentration of less than 0.1 M and comprises hypophosphorous acid, squaric acid, dihydroxyfumaric acid, or mixtures thereof;

the complexing agent has a concentration from 0.1 to 200 mM;

the dielectric etchant is present at a concentration from 1 to 100 mM and comprises one or more of a hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, tetrafluoroborate, hexafluorosilicate, and mixtures thereof; and

the aqueous cleaning solution has a pH less than or equal to 3.

CLAIMS

What is claimed is:

1. A cleaning solution comprising:
    a corrosion inhibitor;
    a solubilizing agent;
    an oxygen scavenger; and
    a complexing agent also capable as a pH adjustor.

2. The cleaning solution of claim 1, wherein the corrosion inhibitor is a triazole compound.

3. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a toluol triazole or a benzotriazole.

4. The cleaning solution of claim 1, wherein the corrosion inhibitor is present at a concentration between 0.1 to 10000 ppm and all subranges subsumed therein.

5. The cleaning solution of claim 1, wherein the corrosion inhibitor is present at a concentration between 100 to 2000 ppm and all subranges subsumed therein.

6. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration between 0.1 to 10000 ppm and all subranges subsumed therein.

7. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration between 100 to 2000 ppm and all subranges subsumed therein.

8. The cleaning solution of claim 1, wherein the oxygen scavenger comprises one or more of L-ascorbic acid, D-ascorbic acid, derivatives of ascorbic acid, chlorogenic acid, caffeic acid, luteolin, sulfite, ammonium sulfite, and tetramethylammonium sulfite.

9. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound and the oxygen scavenger comprises L-ascorbic acid.

10. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a toluol triazole or a benzotriazole and the oxygen scavenger comprises L-ascorbic acid.

11. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration between 0.1 to 10000 ppm and all subranges subsumed therein and the oxygen scavenger comprises L-ascorbic acid.

12. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration between 100 to 2000 ppm and all subranges subsumed therein and the oxygen scavenger comprises L-ascorbic acid.

13. The cleaning solution of claim 1, wherein the oxygen scavenger comprises L-ascorbic acid at a concentration between 0 to 10000 ppm and all subranges subsumed therein.

14. The cleaning solution of claim 1, wherein the oxygen scavenger comprises L-ascorbic acid at a concentration between 1000 to 5000 ppm and all subranges subsumed therein.

15. The cleaning solution of claim 1, wherein the complexing agent comprises oxalic acid, pyrophosphoric acid, hydroxyethylidene diphosphonic acid, phytic acid, malonic acid, maleic acid, or mixtures thereof.

16. The cleaning solution of claim 1, wherein the solubilizing agent comprises primary alcohol, secondary alcohol, tertiary alcohol, polyol, ethylene glycol, propylene glycol, 2-n-butoxyethanol, dimethylsulfoxide, propylenecarbonate, or combinations thereof.

17. The cleaning solution of claim 1, wherein the solubilizing agent comprises dimethylsulfoxide.

18. The cleaning solution of claim 1, wherein the solubilizing agent comprises isopropyl alcohol.

19. The cleaning solution of claim 1, wherein:

the corrosion inhibitor comprises a triazole compound;

the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, propylene glycol, 2-n-butoxyethanol, and isopropyl alcohol;

the oxygen scavenger comprises L-ascorbic acid; and

the complexing agent comprises oxalic acid.

20. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a toluol triazole or a benzotriazole; the solvent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol; the oxygen scavenger comprises L-ascorbic acid; and the complexing agent comprises oxalic acid.

21. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration between 0.1 to 10000 ppm and all subranges subsumed therein; the oxygen scavenger comprises L-ascorbic acid; and the complexing agent comprises oxalic acid.

22. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration between 100 to 2000 ppm and all subranges subsumed therein; the oxygen scavenger comprises L-ascorbic acid; and the complexing agent comprises oxalic acid.

23. The cleaning solution of claim 1, wherein the oxygen scavenger comprises L-ascorbic acid at a concentration between 0 to 10000 ppm and all subranges subsumed therein; and the complexing agent comprises oxalic acid.

24. The cleaning solution of claim 1, wherein the oxygen scavenger comprises L-ascorbic acid at a concentration between 1000 to 5000 ppm and all subranges subsumed therein; and the complexing agent comprises oxalic acid.

25. The cleaning solution of claim 1, wherein the complexing agent comprises oxalic acid, pyrophosphoric acid, hydroxyethylidene diphosphonic acid, phytic acid, malonic acid, maleic acid, or mixtures thereof at a concentration from 2 to 50 g/L and all subranges subsumed therein.

26. The cleaning solution of claim 1, wherein:

the corrosion inhibitor comprises a triazole compound at a concentration between 0.1 to 10000 ppm and all subranges subsumed therein;

the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol at a concentration up to 200 mL/L;

the oxygen scavenger comprises L-ascorbic acid at a concentration between 0 to 10000 ppm and all subranges subsumed therein; and

the complexing agent comprises oxalic acid at a concentration between 0.5 to 20 g/L and all subranges subsumed therein.

27. The cleaning solution of claim 1, wherein:

the corrosion inhibitor comprises a triazole compound at a concentration from 100 to 2000 ppm and all subranges subsumed therein;

the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol at a concentration from 1 to 200 mL/L and all subranges subsumed therein;

the oxygen scavenger comprises L-ascorbic acid at a concentration from 1000 to 5000 ppm and all subranges subsumed therein; and

the complexing agent comprises oxalic acid at a concentration between 0.5 to 20 g/L and all subranges subsumed therein.

28. The cleaning solution of claim 1, wherein:

the corrosion inhibitor comprises 5-methylbenzotriazole at a concentration of 1 g/L;

the solubilizing agent comprises ethylene glycol at a concentration of 50 mL/L;

the oxygen scavenger comprises L-(+)-ascorbic acid at a concentration of 1 g/L; and

the complexing agent comprises oxalic acid dihydrate at a concentration of 10 g/L.

29. The cleaning solution of claim 1, wherein the corrosion inhibitor is a triazole compound and the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol.

30. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a toluol triazole or a benzotriazole and the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol.

31. The cleaning solution of claim 1, wherein the corrosion inhibitor is present at a concentration between 0.1 to 10000 ppm and all subranges subsumed therein and the solubilizing agent is present at a concentration up to 200 mL/L.

32. The cleaning solution of claim 1, wherein the corrosion inhibitor is present at a concentration between 100 to 2000 ppm and all subranges subsumed therein and the solubilizing agent is present at a concentration between 1 to 200 mL/L and all subranges subsumed therein.

33. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration from 0.1 to 10000 ppm and all subranges subsumed therein and the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol at a concentration up to 50 mL/L.

34. The cleaning solution of claim 1, wherein the corrosion inhibitor comprises a triazole compound at a concentration from 100 to 2000 ppm and all subranges subsumed therein and the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, and isopropyl alcohol at a concentration from 1 to 200 mL/L and all subranges subsumed therein.

35. The cleaning solution of claim 1, wherein:

the corrosion inhibitor comprises 5-methylbenzotriazole at a concentration of 1 g/L;
the solubilizing agent comprises isopropyl alcohol at a concentration of 50 mL/L;
the oxygen scavenger comprises L-(+)-ascorbic acid at a concentration of 1 g/L; and
the complexing agent comprises oxalic acid dihydrate at a concentration of 10 g/L.

36. The cleaning solution of claim 1, wherein:

the corrosion inhibitor comprises 5-methylbenzotriazole at a concentration of 1 g/L;
the solubilizing agent comprises dimethyl sulfoxide at a concentration up to 1000 mL/L;
the oxygen scavenger comprises L-(+)-ascorbic acid at a concentration of 1 g/L; and
the complexing agent comprises oxalic acid dihydrate at a concentration of 10 g/L.

37. The cleaning solution of claim 1, wherein the oxygen scavenger comprises D-ascorbic acid, a derivative of ascorbic acid, and/or a sulfite.

38. A cleaning solution comprising:

a pH adjustor;
a complexing agent; and
a corrosion inhibitor;

wherein the cleaning solution has a pH less than or equal to 3.

39. The cleaning solution of claim 38, wherein the pH is less than or equal to 2.

40. The cleaning solution of claim 38, further comprising a solubilizing agent.

41. The cleaning solution of claim 38, further comprising a solubilizing agent capable of solubilizing the corrosion inhibitor.

42. The cleaning solution of claim 38, further comprising a surfactant.

43. The cleaning solution of claim 38, further comprising a dielectric etchant.

44. The cleaning solution of claim 38, further comprising a solubilizing agent and a surfactant.

45. The cleaning solution of claim 38, further comprising one or more of:

a solubilizing agent,

a dielectric etchant, and

a surfactant.

46. The cleaning solution of claim 38, wherein the complexing agent includes carboxylic acids, hydroxycarboxylic acids, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, phytic acid, or mixtures thereof.

47. The cleaning solution of claim 38, wherein the pH adjustor includes sulphuric acid, sulfonic acid, methanesulfonic acid, benzene sulfonic acid, triflic acid, hypophosphorous acid, oxalic acid, halogenated carboxylic acids, trifluoroacetic acid, acetylenedicarboxylic acid, squaric acid, dihydroxyfumaric acid, maleic acid, or mixtures thereof.

48. The cleaning solution of claim 38, wherein the pH adjustor includes one or more acids having pK_a equal to or less than 2, and the one or more acids being capable to adjust the cleaning solution to a pH less than or equal to 3.

49. The cleaning solution of claim 38, wherein the pH adjustor includes one or more acids having pK_a equal to or less than 1.5 and the one or more acids being capable to adjust the cleaning solution to a pH less than or equal to 3.

50. The cleaning solution of claim 38, wherein the corrosion inhibitor comprises one or more of triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate, alkylphosphate, orthophosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, derivatives thereof, and combinations thereof.

51. The cleaning solution of claim 38, further comprising a solubilizing agent selected from the group consisting of primary alcohol, secondary alcohol, tertiary alcohol, polyol, ethylene glycol, dimethylsulfoxide, propylenecarbonate, and combinations thereof.

52. The cleaning solution of claim 38, further comprising ethylene glycol.

53. The cleaning solution of claim 38, further comprising isopropyl alcohol.

54. The cleaning solution of claim 38, further comprising dimethylsulfoxide.

55. The cleaning solution of claim 38, further comprising a surfactant selected from the group consisting of anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, and combinations thereof.

56. The cleaning solution of claim 38, further comprising a surfactant that includes a sulfate and/or a sulphonate.

57. The cleaning solution of claim 38, further comprising a dielectric etchant capable of etching silicon-oxygen compounds.

58. The cleaning solution of claim 38, further comprising a dielectric etchant selected from the group consisting of hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal salts of fluoride, tetrafluoroborate, hexafluorosilicate, and mixtures thereof.

59. An aqueous cleaning solution comprising:

a pH adjustor;

a complexing agent;

a corrosion inhibitor; and

one or more of:

a solubilizing agent,

a dielectric etchant, and

a surfactant.

60. The aqueous cleaning solution of claim 59, wherein the pH adjustor is substantially non-complexing.

61. The aqueous cleaning solution of claim 59, wherein the pH adjustor comprises a first acid and the complexing agent comprises a second acid.

62. The aqueous cleaning solution of claim 59, wherein:

the pH adjustor includes sulphuric acid, sulfonic acid, methanesulfonic acid, benzene sulfonic acid, triflic acid, hypophosphorous acid, oxalic acid, halogenated carboxylic acids, trifluoroacetic acid, acetylenedicarboxylic acid, squaric acid, dihydroxyfumaric acid, maleic acid, or mixtures thereof; and

the complexing agent includes carboxylic acids, hydroxycarboxylic acids, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, phytic acid, or mixtures thereof.

63. The aqueous cleaning solution of claim 59, wherein the pH adjustor comprises a strong acid.

64. The aqueous cleaning solution of claim 59, wherein:

the pH adjustor includes sulphuric acid, sulfonic acid, methanesulfonic acid, benzene sulfonic acid, triflic acid, hypophosphorous acid, oxalic acid, halogenated carboxylic acids, trifluoroacetic acid, acetylenedicarboxylic acid, squaric acid, dihydroxyfumaric acid, maleic acid, or mixtures thereof;

the complexing agent includes carboxylic acids, hydroxycarboxylic acids, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, phytic acid, or mixtures thereof;

the corrosion inhibitor comprises triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate,

alkylphosphate, orthophosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, derivatives thereof, and combinations thereof;

the solubilizing agent comprises one or more of dimethylsulfoxide, ethylene glycol, propylene glycol, 2-n-butoxyethanol, and isopropyl alcohol;

the dielectric etchant comprises one or more of hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal salts of fluoride, tetrafluoroborate, hexafluorosilicate, and mixtures thereof; and

the surfactant comprises anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, or combinations thereof;

the aqueous cleaning solution has a pH less than or equal to 3.

65. The aqueous cleaning solution of claim 59, wherein:

the pH adjustor has a concentration of between 0 to 0.1 M and all ranges subsumed therein;

the complexing agent has a concentration from 0.1 to 200 mM and all ranges subsumed therein;

the corrosion inhibitor has a concentration from 0.1 to 50 mM and all ranges subsumed therein;

the solubilizing agent has a concentration from 0 to 200 mL/L and all ranges subsumed therein;

the dielectric etchant has a concentration from 1 to 100 mM and all ranges subsumed therein; and

the surfactant has a concentration from 0 to 2000 ppm and all ranges subsumed therein;

the aqueous cleaning solution has a pH less than or equal to 3.

66. The aqueous cleaning solution of claim 59, wherein:

the pH adjustor has a concentration of less than 0.1 M and includes sulphuric acid, sulfonic acid, methanesulfonic acid, benzene sulfonic acid, triflic acid, hypophosphorous acid, oxalic acid, halogenated carboxylic acids, trifluoroacetic acid, acetylenedicarboxylic acid, squaric acid, dihydroxyfumaric acid, maleic acid, or mixtures thereof;

the complexing agent has a concentration from 0.1 to 200 mM and includes carboxylic acid, hydroxycarboxylic acid, citric acid, oxalic acid, phosphonic acid, hydroxyethylidene diphosphonic acid, phytic acid, or combinations thereof;

the corrosion inhibitor has a concentration from 0.1 to 50 mM and comprises triazole, benzotriazole, methyl-benzotriazole, 5-methyl-benzotriazole, carboxy-benzotriazole, hydroxybenzotriazole, mercaptobenzothiazole, polyvinylpyrrolidone, polyvinylalcohol, polyamine, polyimine, polyalkylimine, polyethylenimine, long chain alkylamine, tetrazole, phosphate, inorganic phosphate, alkylphosphate, orthophosphate, metaphosphate, phosphite, phosphonate, fluoroalkylphosphate, silicate, alkylphosphonate, fluoroalkylphosphonate, alkoxysilane, nitrite, bicyclohexylammonium nitrite, derivatives thereof, or combinations thereof;

the solubilizing agent is present at a concentration less than 200 mL/L and comprises one or more of primary alcohol, secondary alcohol, tertiary alcohol, polyol, ethylene glycol, propylene glycol, 2-n-butoxyethanol, dimethylsulfoxide, propylenecarbonate, and combinations thereof;

the dielectric etchant is present at a concentration from 1 to 100 mM and comprises one or more of hydrogen fluoride, hydrogen tetrafluoroborate, hydrogen hexafluorosilicate, non-alkali metal salts of fluoride, tetrafluoroborate, hexafluorosilicate, and mixtures thereof; and

the surfactant is present at a concentration of less than 2000 ppm and comprises anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, or combinations thereof;

the aqueous cleaning solution has a pH less than or equal to 3.