Claims

1. A Chemical Mechanical Planarization polishing composition comprising, consisting essentially of, or consisting of:

   a) abrasive;

   b) cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring;

   c) oxidizer; and

   d) water-soluble solvent ;

   optionally at least one of

   e) corrosion inhibitor;

   f) chemical additive;

   g) biocide;

   and

   h) pH adjusting agent;

   wherein the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring contains a polar group and is selected from the group consisting of 1,4,8,12-Tetraazacyclopentadecane; 2-(1H-Pyrazol-3-yl)pyridine; 2-(1H-Imidazol-2-yl)pyridine; 4,5-Diazafluoren-9-one; 2-(2-Pyridyl)benzimidazole; 2,6-Di(2H-1,2,3-triazol-4-yl)pyridine; 2,2′-Bicinchoninic Acid; 2-(Pyridin-2-yl)-1H-pyrrolo[2,3-b]pyridine; 2,6-Di(1H-pyrazol-3-yl)pyridine; 2,6-Di(1H-pyrazol-1-yl)isonicotinic acid; 2-(1H-Imidazol-2-yl)pyridine-4-carboxylic acid; 2,2′-bipyrazine; purine; 2,2′-Bipyrimidine; 7-Amino-1H-indazole; Thiopicolinamide; Picolinimidamide Hydrochloride; Pyridine-2,6-dicarboximidamide Dihydrochloride; 2-(1H-Tetrazol-5-yl)pyridine; 2-(1H-1,2,4-Triazol-3-yl)pyridine; 4,7-Dihydroxy-1,10-phenanthroline; Pyrazino[2,3-f][1,10]phenanthroline; Bathophenanthrolinedisulfonic Acid Disodium Salt Hydrate; 1,10-Phenanthroline-2,9-Dicarboxylic Acid; 1,10-Phenanthroline-4,7-dicarboxylic acid; 2,6-Bis(4,5-dihydrooxazol-2-yl)pyridine; 2-(4,5-Dihydro-2-oxazolyl)pyridine; Bis[(1H-pyrazol-5-yl)methyl]amine; Bis[(1H-pyrrol-2-yl)methyl]amine; 2-(1H-Pyrazol-1-ylmethyl)pyridine; 8-Aminoquinoline; and combinations thereof; and

   pH of the Chemical Mechanical Planarization polishing composition is ≥ 7 or ≥ 8.

2. The Chemical Mechanical Planarization polishing composition according to Claim 1, wherein the composition comprises 0.0025 wt.% to 25 wt.%, 0.0025 wt.% to 20 wt.%, 0.005 wt.% to 10.0 wt.%, or 0.01 wt.% to 5 wt.% of the abrasive selected from the group consisting of inorganic oxide particles, metal oxide-coated inorganic oxide particles, organic polymer particles, metal oxide-coated organic polymer particles, and combinations thereof.

3. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 2, wherein the abrasive is selected from the group consisting of colloidal silica, cerium oxide, ceria coated silica particles, and combinations thereof.

4. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 3, wherein the Chemical Mechanical Planarization polishing composition comprises 0.0005 wt.% to 5 wt.%; 0.005 wt.% to 0.5 wt.%; or 0.0025 wt.% to 0.05wt.% of the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring is selected from the group consisting of 1,2 - Cyclohexanediamine, 2,6-Di(2H-1,2,3-triazol-4-yl)pyridine, 2,6-Di(1H-pyrazol-3-yl)pyridine, Di-(2-picolyl)amine, 2-(1H-1,2,4-Triazol-3-yl)pyridine, 8-Aminoquinoline, 3,6-Di(2-pyridyl)-1,2,4,5-tetrazine, and combinations thereof.

5. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 4, wherein the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring is selected from the group consisting of 2,6-Di(2H-1,2,3-triazol-4-yl)pyridine, 2,6-Di(1H-pyrazol-3-yl)pyridine, 2-(1H-1,2,4-Triazol-3-yl)pyridine, 8-Aminoquinoline, and combinations thereof.

6. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 5, wherein the Chemical Mechanical Planarization polishing composition comprises 0.1 wt.% to 10 wt.%; 0.25 wt.% to 3 wt.%; or 0.5 wt.% to 2.0 wt.% oxidizer of the oxidizer selected from the group consisting of hydrogen peroxide, urea peroxide, peroxyformic acid, peracetic acid, propaneperoxoic acid, substituted or unsubstituted butaneperoxoic acid, hydroperoxy-acetaldehyde, potassium periodate, ammonium peroxymonosulfate; and non-per-oxy compound selected from the group consisting of ferric nitrite, $KClO_4$, $KBrO_4$, $KMnO_4$; and combinations thereof.

7. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 6, wherein the Chemical Mechanical Planarization polishing composition further comprises 0.005 wt.% to 1.0 wt.%, 0.01 wt.% to 0.5 wt.%; or 0.02 wt.% to 0.2 wt.% of the corrosion inhibitor selected from the group consisting of benzotriazole and benzotriazole derivatives, tetrazole and tetrazole derivatives, imidazole and imidazole derivatives, benzimidazole and benzimidazole derivatives, pyrazole and pyrazole derivatives, tetrazole and tetrazole derivatives; and non-triazole corrosion inhibitor.

8. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 7, wherein the Chemical Mechanical Planarization polishing composition further comprises 0.005 wt.% to 5.0 wt.%, 0.01 wt.% to 0.5 wt.%; or 0.02 wt.% to 0.2 wt.% of the chemical additive selected from the group consisting of inorganic silicate, polyacrylic acid and its salts, ammonium hydroxide, and a chelator which is not a cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring, and combinations thereof.

9. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 8, wherein the Chemical Mechanical Planarization polishing composition further comprises 0.0001 wt.% to 0.05 wt.%; 0.0002 wt.% to 0.025 wt.%; or 0.002 wt.% to 0.01 wt.% of a biocide having an active ingredient of 5-chloro-2-methyl-4-isothiazolin-3-one, 2-methyl-4-isothiazolin-3-one, or combinations thereof.

10. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 9, wherein the water-soluble solvent is selected from the group consisting of deionized (DI) water, distilled water, organic alcohol, and combinations thereof; DI water is preferred.

11. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 10, wherein the Chemical Mechanical Planarization polishing composition further comprises pH adjusting agent selected from the group consisting of nitric acid, sulfuric acid, tartaric acid, succinic acid, citric acid, malic acid, malonic acid, various fatty acids, various polycarboxylic acids, potassium

hydroxide, sodium hydroxide, ammonia, tetraethylammonium hydroxide, piperazine, polyethyleneimine, modified polyethyleneimine, and mixtures thereof.

12. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 11, wherein the composition has a pH of 7 to 12, or 8 to 12.

13. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 12, wherein the Chemical Mechanical Planarization polishing composition comprises colloidal silica; the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring selected from the group consisting of 1,2 -Cyclohexanediamine, 2,6-Di(2H-1,2,3-triazol-4-yl)pyridine, 2,6-Di(1H-pyrazol-3-yl)pyridine, Di-(2-picolyl)amine, 2-(1H-1,2,4-Triazol-3-yl)pyridine, 8-Aminoquinoline, 3,6-Di(2-pyridyl)-1,2,4,5-tetrazine, and combinations thereof; hydrogen peroxide; water and the composition has a pH of 7 to 12 or 8 to 12.

14. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 13, wherein the Chemical Mechanical Planarization polishing composition comprises colloidal silica; the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring selected from the group consisting of 1,2 -Cyclohexanediamine, 2,6-Di(2H-1,2,3-triazol-4-yl)pyridine, 2,6-Di(1H-pyrazol-3-yl)pyridine, Di-(2-picolyl)amine, 2-(1H-1,2,4-Triazol-3-yl)pyridine, 8-Aminoquinoline, and combinations thereof, hydrogen peroxide; water and the composition has a pH of 7 to 12 or 8 to 12.

15. The Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 14, wherein the Chemical Mechanical Planarization polishing composition comprises colloidal silica; the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring selected from the group consisting of 1,2 -Cyclohexanediamine, 2,6-Di(2H-1,2,3-triazol-4-yl)pyridine, 2,6-Di(1H-pyrazol-3-yl)pyridine, Di-(2-picolyl)amine, 2-(1H-1,2,4-Triazol-3-yl)pyridine, 8-Aminoquinoline, and combinations thereof; hydrogen peroxide; ammonium hydroxide; potassium silicate, Poly(Acrylic acid) ammonium salt, benzotriazole, water and the composition has a pH of 7 to 11 or 8 to 11.

16. A Chemical Mechanical Planarization polishing method for chemical mechanical planarization of a semiconductor substrate comprising at least one surface containing Ru comprising, consisting essentially of, or consisting of the steps of:
providing the Chemical Mechanical Planarization polishing composition according to any one of Claims 1 - 15;
providing a polishing pad;
contacting the at least one surface containing Ru with the polishing pad and the chemical mechanical planarization polishing composition;
polishing the at least one surface containing Ru.

17. The Chemical Mechanical Planarization polishing method of Claim 16, wherein the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring in the chemical mechanical planarization polishing composition inhibits removal of Cu.

18. A Chemical Mechanical Planarization polishing system, comprising, consisting essentially of, or consisting of:
a semiconductor substrate comprising at least one surface containing Ru;
a polishing pad; and
the chemical mechanical planarization polishing composition according to any one of Claims 1 - 15;
wherein the at least one surface containing Ru is in contact with the polishing pad and the chemical mechanical planarization composition.

19. The Chemical Mechanical Planarization polishing system of Claim 18, wherein the cyclic chelator comprising at least one N-C-C-N group and at least one cyclic ring in the chemical mechanical planarization polishing composition inhibits removal of Cu.