Claims

1. A chemical mechanical polishing (CMP) composition comprising:

an abrasive;

polyurethane (PU) beads;

a silicone-containing dispersing agent;

water;

a chelating agent selected from the group consisting of amino acid and its derivatives, organic amine, and combinations thereof;

and

optionally at least one selected from the group consisting of

~~a chelating agent selected from the group consisting of amino acid and its derivatives, organic amine, and combinations thereof;~~

a corrosion inhibitor;

an organic quaternary ammonium salt;

a biocide;

a pH adjusting agent; and

an oxidizer;

wherein the pH of the composition is from 3.0 to 12.0~~; 5.5 to 7.5; or 6.0 to 7.5~~.

2. The CMP composition of Claim 1, wherein the abrasive are abrasive particles selected from the group consisting of colloidal silica; colloidal silica particles doped by other metal oxide within lattice of the colloidal silica; colloidal aluminum oxide selected from the group consisting of alpha-, beta-, and gamma-types of aluminum oxides; colloidal and photoactive titanium dioxide; cerium oxide; colloidal cerium oxide; inorganic metal oxide particles selected from the group consisting of alumina, titania, zirconia, and ceria; diamond particles; silicon nitride particles; mono-modal, bi-modal, or multi-modal colloidal abrasive particles; organic polymer-based soft abrasive particles; surface-coated or modified abrasive particles; and combinations thereof; and the abrasive ranges from ~~0.0025 wt.% to 25 wt.%; 0.0025 wt.% to 2.5 wt.%;~~ 0.005 wt.% to 0.5 wt.%~~; or 0.005 wt.% to 0.15 wt.%~~.

3. The CMP composition of Claim 1, wherein the polyurethane (PU) beads have a size from ~~2 to 100 μm,~~ 10 to 80 μm~~, 20 to 70 μm, or 30 to 50 μm~~; and the polyurethane (PU) beads range from ~~0.01 wt.% to 2.0 wt.%,~~ 0.025 wt.% to 1.0 wt.%~~, or 0.05 wt.% to 0.5 wt.%~~.

4. The CMP composition of Claim 1, wherein the silicone-containing dispersing agent comprises a silicone polyether containing both a water-insoluble silicone backbone and water-soluble polyether pendant groups, and the silicone-containing dispersing agent ranges from ~~0.01 wt.% to 2.0 wt.%,~~ 0.025 wt.% to 1.0 wt.%~~, or 0.05 wt.% to 0.5 wt.%.~~.

5. The CMP composition of Claim 1, wherein the silicone-containing dispersing agent comprises a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups, wherein n is 2 to 25; and the silicone-containing dispersing agent ranges from 0.025 wt.% to 1.0 wt.%.

6. The CMP composition of Claim 1, wherein the CMP composition comprises the chelating agent selected from the group consisting of glycine, D-alanine, L-alanine, DL-alanine, beta-alanine, valine, leucine, isolueciene, phenylamine, proline, serine, threonine, tyrosine, glutamine, asparanine, glutamic acid, aspartic acid, tryptophan, histidine, arginine, lysine, methionine, cysteine, iminodiacetic acid, 2,2-dimethyl-1,3-propanediamine and 2,2-dimethyl-1,4-butanediamine, ethylenediamine, 1,3-diaminepropane, 1,4-diaminebutane, and combinations thereof; and the chelating agent ranges from ~~0.1 wt.% to 18 wt.%;~~ 0.5 wt.% to 15 wt.%~~; 1.0 wt.% to 10.0 wt.%; or 2.0 wt.% to 10.0 wt.%~~.

7. The CMP composition of Claim 1, wherein the CMP composition further comprises the corrosion inhibitor selected from the group consisting of 1,2,4-triazole, 3-amino-1,2,4-triazole, 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 combinations thereof; and the corrosion inhibitor ranges from 0.005 wt.% to 1.0 wt.%~~; 0.01 wt.% to 0.5 wt.%; or 0.025 wt.% to 0.25 wt.%~~.

8. The CMP composition of Claim 1, wherein the CMP composition comprises the abrasive selected from the group consisting of colloidal silica; colloidal silica particles doped by other metal oxide within lattice of the colloidal silica; colloidal aluminum oxide selected from the group consisting of alpha-, beta-, and gamma-types of aluminum oxides; colloidal and photoactive titanium dioxide; cerium oxide; colloidal cerium oxide; inorganic

metal oxide particles selected from the group consisting of alumina, titania, zirconia, and ceria; diamond particles; silicon nitride particles; mono-modal, bi-modal, or multi-modal colloidal abrasive particles; organic polymer-based soft abrasive particles; surface-coated or modified abrasive particles; and combinations thereof;

the polyurethane (PU) beads have a size from ~~2 to 100 μm,~~ 10 to 80 μm, or 20 to 70 μm~~, or 30 to 50 μm~~;

the silicone-containing dispersing agent comprises a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25;

the chelating agents selected from the group consisting of the group consisting of glycine, D-alanine, L-alanine, DL-alanine, beta-alanine, valine, leucine, isolueciene, phenylamine, proline, serine, threonine, tyrosine, glutamine, asparanine, glutamic acid, aspartic acid, tryptophan, histidine, arginine, lysine, methionine, cysteine, iminodiacetic acid, 2,2-dimethyl-1,3-propanediamine and 2,2-dimethyl-1,4-butanediamine, ethylenediamine, 1,3-diaminepropane, 1,4-diaminebutane, and combinations thereof; and

the corrosion inhibitor selected from the group consisting of 1,2,4-triazole, 3-amino-1,2,4-triazole, 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 combinations thereof.

**9.** The CMP composition of Claim 1, wherein the CMP composition further comprises the biocide having an active ingredient selected from the group consisting of 5-chloro-2-methyl-4-isothiazolin-3-one, 2-methyl-4-isothiazolin-3-one, and combinations thereof; and the biocide ranges from 0.0001 wt.% to 0.05 wt.%~~; 0.0001 wt.% to 0.025 wt.%; or 0.0001 wt.% to 0.01 wt.%~~.

**10.** The CMP composition of Claim 1, wherein the CMP composition comprises the oxidizing agent selected from the group consisting of periodic acid, hydrogen peroxide, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, and combinations thereof; and the oxidizing agent ranges from 0.1 wt.% to 10 wt.%~~; 0.25wt.% to 3 wt.%; or 0.5wt.% to 2.0wt.%~~.

**11.** The CMP composition of Claim 1, wherein the CMP composition comprises

the abrasive selected from the group consisting of colloidal silica; colloidal silica particles doped by other metal oxide within lattice of the colloidal silica; colloidal aluminum oxide selected from the group consisting of alpha-, beta-, and gamma-types of aluminum oxides; colloidal and photoactive titanium dioxide; cerium oxide; colloidal cerium oxide; inorganic metal oxide particles selected from the group consisting of alumina, titania, zirconia, and ceria; diamond particles; silicon nitride particles; mono-modal, bi-modal, or multi-modal colloidal abrasive particles; organic polymer-based soft abrasive particles; surface-coated or modified abrasive particles; and combinations thereof;

the polyurethane (PU) beads have a size from ~~2 to 100 μm,~~ 10 to 80 μm~~, 20 to 70 μm, or 30 to 50 μm~~;

the silicone-containing dispersing agent comprises a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25;

the chelating agents selected from the group consisting of the group consisting of glycine, D-alanine, L-alanine, DL-alanine, beta-alanine, valine, leucine, isolueciene, phenylamine, proline, serine, threonine, tyrosine, glutamine, asparanine, glutamic acid, aspartic acid, tryptophan, histidine, arginine, lysine, methionine, cysteine, iminodiacetic acid, 2,2-dimethyl-1,3-propanediamine and 2,2-dimethyl-1,4-butanediamine, ethylenediamine, 1,3-diaminepropane, 1,4-diaminebutane, and combinations thereof;

the oxidizing agent selected from the group consisting of periodic acid, hydrogen peroxide, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, and combinations thereof; and

the corrosion inhibitor selected from the group consisting of 1,2,4-triazole, 3-amino-1,2,4-triazole, 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 combinations thereof.

**12.** The CMP composition of Claim 1, wherein the CMP composition comprises the organic quaternary ammonium salt selected from the group consisting of choline salt having different counter ions selected from the group consisting of choline bicarbonate, choline hydroxide, choline dihydrogencitrate salt, choline ethanolamine, choline bitartrate, and combinations thereof; and the organic quaternary ammonium salt ranges from 0.005 wt.% to 0.25 wt.%~~, 0.001 wt.% to 0.05 wt.%; or 0.002 wt.% to 0.01 wt.%~~.

13. The CMP composition of Claim 1, wherein the CMP composition comprises

the abrasive selected from the group consisting of colloidal silica; colloidal silica particles doped by other metal oxide within lattice of the colloidal silica; colloidal aluminum oxide selected from the group consisting of alpha-, beta-, and gamma-types of aluminum oxides; colloidal and photoactive titanium dioxide; cerium oxide; colloidal cerium oxide; inorganic metal oxide particles selected from the group consisting of alumina, titania, zirconia, and ceria; diamond particles; silicon nitride particles; mono-modal, bi-modal, or multi-modal colloidal abrasive particles; organic polymer-based soft abrasive particles; surface-coated or modified abrasive particles; and combinations thereof;

the polyurethane (PU) beads have a size from ~~2 to 100 μm,~~ 10 to 80 μm~~, 20 to 70 μm, or 30 to 50 μm~~;

the silicone-containing dispersing agent comprises a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25;

the chelating agents selected from the group consisting of the group consisting of glycine, D-alanine, L-alanine, DL-alanine, beta-alanine, valine, leucine, isolueciene, phenylamine, proline, serine, threonine, tyrosine, glutamine, asparanine, glutamic acid, aspartic acid, tryptophan, histidine, arginine, lysine, methionine, cysteine, iminodiacetic acid, 2,2-dimethyl-1,3-propanediamine and 2,2-dimethyl-1,4-butanediamine, ethylenediamine, 1,3-diaminepropane, 1,4-diaminebutane, and combinations thereof;

the corrosion inhibitor selected from the group consisting of 1,2,4-triazole, 3-amino-1,2,4-triazole, 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 combinations thereof;

the oxidizing agent selected from the group consisting of periodic acid, hydrogen peroxide, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, and combinations thereof; and

the organic quaternary ammonium salt selected from the group consisting of choline salt having different counter ions selected from the group consisting of choline bicarbonate, choline hydroxide, choline dihydrogencitrate salt, choline ethanolamine, choline bitartrate, and combinations thereof.

14. The CMP composition of Claim 1, wherein the CMP composition comprises the pH adjusting agent selected from the group consisting of nitric acid, hydrochloric acid, sulfuric acid, phosphoric acid, other inorganic or organic acids, and combinations thereof to adjust pH towards acidic direction; or is selected from the group consisting of sodium hydride, potassium hydroxide, ammonium hydroxide, tetraalkyl ammonium hydroxide, organic amines, and combinations thereof to adjust pH towards alkaline direction; and the CMP composition has a pH of about 5.5 to about 9.0 ~~about 6.0 to about 8.0; or about 6.0 to about 7.5~~.

~~15. The CMP composition of Claim 1, wherein the CMP composition comprises colloidal silica particles, silicone-containing dispersing agent comprising a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 o 25, and polyurethane (PU) beads.~~

~~16. The CMP composition of Claim 1, wherein the CMP composition comprises colloidal silica particles; silicone-containing dispersing agent comprising a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 o 25; polyurethane (PU) beads; the chelating agent selected from the group consisting of the group consisting of glycine, D-alanine, L-alanine, DL-alanine, beta-alanine, valine, leucine, isolueciene, phenylamine, proline, serine, threonine, tyrosine, glutamine, asparanine, glutamic acid, aspartic acid, tryptophan, histidine, arginine, lysine, methionine, cysteine, iminodiacetic acid, 2,2-dimethyl-1,3-propanediamine and 2,2-dimethyl-1,4-butanediamine, ethylenediamine, 1,3-diaminepropane, 1,4-diaminebutane, and combinations thereof; and the corrosion inhibitor selected from the group consisting of 1,2,4-triazole, 3-amino-1,2,4-triazole, 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 combinations thereof.~~

~~17.~~15. The CMP composition of Claim 1, wherein the CMP composition comprises colloidal silica particles; silicone-containing dispersing agent comprising a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25; polyurethane (PU) beads; at least two ~~the~~ chelating agent selected from

the group consisting of the group consisting of glycine, D-alanine, L-alanine, DL-alanine, beta-alanine, valine, leucine, isolueciene, phenylamine, proline, serine, threonine, tyrosine, glutamine, asparanine, glutamic acid, aspartic acid, tryptophan, histidine, arginine, lysine, methionine, cysteine, iminodiacetic acid, 2,2-dimethyl-1,3-propanediamine and 2,2-dimethyl-1,4-butanediamine, ethylenediamine, 1,3-diaminepropane, 1,4-diaminebutane, and combinations thereof; the corrosion inhibitor selected from the group consisting of 1,2,4-triazole, 3-amino-1,2,4-triazole, 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 combinations thereof; and the oxidizing agent selected from the group consisting of periodic acid, hydrogen peroxide, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, and combinations thereof;

~~18.~~ **16.** The CMP composition of Claim 1, wherein the CMP composition comprises glycine, amitrole, ethylenediamine, choline bicarbonate, biocide, colloidal silica particles, silicone-containing dispersing agent comprising a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25, and polyurethane (PU) beads.

~~19.~~ **17.** The CMP composition of Claim 1, wherein the CMP composition comprises glycine, amitrole, ethylenediamine, choline bicarbonate, biocide, colloidal silica particles, silicone-containing dispersing agent comprising a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25, and polyurethane (PU) beads; wherein the CMP composition comprises has a pH of 5.5 to 9.0.

~~20.~~ **18.** The CMP composition of Claim 1, wherein the CMP composition comprises glycine, amitrole, ethylenediamine, choline bicarbonate, biocide, and colloidal silica particles, silicone-containing dispersing agent comprising a silicone polyether containing both a water-insoluble silicone backbone and pendant groups comprising n repeating unit of ethylene oxide(EO) and propylene oxide (PO) (EO-PO) functional groups wherein n is 2 to 25, and polyurethane (PU) beads; wherein the CMP composition comprises has a pH of 6.0 to 8.0.

~~21.~~ 19. A method of chemical mechanical polishing a semiconductor substrate, comprising steps of:

providing the semiconductor substrate having a surface containing Copper or THROUGH-SILICON VIA (TSV) Copper;

providing a polishing pad;

providing the chemical mechanical polishing (CMP) composition ~~according to any one~~ of ~~claims~~ claim 1 ~~to 20~~;

contacting the surface of the semiconductor substrate with the polishing pad and the chemical mechanical polishing (CMP) composition; and

polishing the surface containing Copper or TSV Copper.

~~22.~~ 20. A system of chemical mechanical polishing, comprising

a semiconductor substrate having a surface containing copper or THROUGH-SILICON VIA (TSV) copper;

a polishing pad;

the chemical mechanical polishing (CMP) composition ~~in any one~~ of ~~claims~~ claim 1 ~~to 20~~;

wherein at least a portion of the surface containing copper or TSV copper is in contact with both the polishing pad and the chemical mechanical polishing formulation.