

Claims

1. A copper chemical mechanical planarization (CMP) polishing formulation comprising:
abrasive particles selected from the group consisting of fumed silica, colloidal silica, high purity colloidal silica, fumed alumina, colloidal alumina, cerium oxide,
5 titanium dioxide, zirconium oxide, surface modified or lattice doped inorganic oxide particles, polystyrene, polymethyl methacrylate, mica, hydrated aluminum silicate, and combinations thereof;
at least two amino acids,
oxidizer,
10 corrosion inhibitor,
and
liquid carrier.
wherein
the formulation has a pH from 2 to 12; and
15 the abrasive particles have mean particle size (MPS) of 3 to 50 nm, 3 to 40 nm,
4 ~~nm~~ to 30 nm, or 5 to 20 nm.
2. The chemical mechanical planarization (CMP) polishing formulation of claim 1,
wherein the abrasive particles range from 0.0001 to 2.5 wt.%, 0.0005 to 1.0 wt.%,
20 0.001 to 0.5 wt.%, 0.005 to 0.5 wt.%, or 0.01 to 0.25 wt.%.
3. The chemical mechanical planarization (CMP) polishing formulation of claim 1,
wherein the abrasive particles have mean particle size of ≤ 40 nm, ≤ 30 nm, or $\leq$
25 20nm.
4. The chemical mechanical planarization (CMP) polishing formulation of claim 1,
wherein the abrasive particles range from 0.005 to 0.5 wt.%, or 0.01 to 0.25 wt.%
5. The chemical mechanical planarization (CMP) polishing formulation of claim 1,
30 wherein the at least two amino acids are each independently selected from the group consisting of aminoacetic acid (glycine), serine, lysine, glutamine, L-alanine, DL-

alanine, Beta-alanine, iminoacetic acid, asparagine, aspartic acid, valine, sarcosine, bicine, tricin, proline, and combinations thereof; and weight concentration ratio of one amino acid to another amino acid used in the slurry ranges from 1:99 to 99:1; 10:90 to 90:10, 20:80 to 80:20, 25:75 to 75:25, 30:70 to 70:30, 40:60 to 60:40, or 50:50.

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6. The chemical mechanical planarization (CMP) polishing formulation of claim 1, wherein each amino acid of the at least two amino acid ranges from 0.01 wt.% to 20.0 wt.%; 0.1 wt.% to 15.0 wt.%, or 0.5 wt. to 10.0 wt.%.

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7. The chemical mechanical planarization (CMP) polishing -formulation of claim 1, wherein the oxidizer is selected from the group consisting of hydrogen peroxide, ammonium dichromate, ammonium perchlorate, ammonium persulfate, benzoyl peroxide, bromates, calcium hypochlorite, ceric sulfate, chlorates, chromium trioxide, ferric trioxide, ferric chloride, iodates, iodine, magnesium perchlorate, magnesium dioxide, nitrates, periodic acid, permanganic acid, potassium dichromate, potassium ferricyanide, potassium permanganate, potassium persulfate, sodium bismuthate, sodium chlorite, sodium dichromate, sodium nitrite, sodium perborate, sulfates, peracetic acid, urea-hydrogen peroxide, perchloric acid, di-t-butyl peroxide, monopersulfates, dipersulfates, and combinations thereof; and the oxidizer ranges from 0.1 wt. % to 20 wt. %, or 0.25 wt. % to 5 wt.%.

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8. The chemical mechanical planarization (CMP) polishing -formulation of claim 1, wherein the corrosion inhibitor is selected from the group consisting of nitrogenous cyclic compound selected from the group consisting of 1, 2, 3-triazole, 1, 2, 4 triazole, 3-amino-1,2,4-triazole, 1, 2, 3-benzotriazole, 5-methylbenzotriazole, benzotriazole, 1-hydroxybenzotriazole, 4-hydroxybenzotriazole, 4-amino-4H-1, 2, 4-triazole, benzimidazole; 5-amino triazole, benzothiazole, triazinethiol, triazinedithiol, and triazinetrithiol; isocyanurate and combinations thereof.

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9. The chemical mechanical planarization (CMP) polishing formulation of claim 1, wherein the ~~oxidizer~~ corrosion inhibitor ranges from 0.1 ppm to 20,000 ppm by weight, 20 ppm to 10,000 ppm by weight, or 50 ppm to 1000 ppm by weight.

10. The chemical mechanical planarization (CMP) polishing formulation of claim 1,
further ~~comprises~~ comprising 5 to 1000ppm, 10 to 500 ppm, or 10 to 100 ppm of
planarization efficiency enhancer selected from the group consisting of choline salt,
an organic amine, and combinations thereof.
11. The chemical mechanical planarization (CMP) polishing -formulation of claim 1,
further ~~comprises~~ comprising 5 to 1000ppm, 10 to 500 ppm, or 10 to 100 ppm of
planarization efficiency enhancer selected from the group consisting of 2-
Hydroxyethyl)trimethylammonium bicarbonate, choline hydroxide, choline p-toluene-
sulfonate, choline bitartrate, ethylene diamine, propylene diamine, and combinations
thereof.
12. The chemical mechanical planarization (CMP) polishing -formulation of claim 1,
further ~~comprises~~ comprising 0.0001 to 1.0 wt. %, 0.0005 to 0.5 wt.%, or 0.001 to 0.3
wt.% of a surfactant ~~containing one~~ selected from the group consisting of phenyl
ethoxylate, acetylenic diol, sulfate, sulfonate, glycerol propoxylate, glycerol
ethoxylate, polysorbate surfactant, non-ionic alkyl ethoxylate, glycerol propoxylate-
block-ethoxylate, amine oxide, glycolic acid ethoxylate oleyl ether, polyethylene
glycol, polyethylene oxide, ethoxylated alcohols, ethoxylate-propoxylate, polyether
defoaming dispersion, and combinations thereof.
13. The chemical mechanical planarization (CMP) polishing -formulation of claim 1,
further ~~comprises~~ comprising 0.0001 to 1.0 wt. %, 0.0005 to 0.5 wt.%, or 0.001 to 0.3
wt.% of a surfactant ~~containing one~~ selected from the group consisting of phenyl
ethoxylate, acetylenic diol, ethoxylate-propoxylate, polyether, sulfate or sulfonate
selected from the group consisting of ammonium dodecyl sulfate, sodium decyl
sulfate, tetradecyl sulfate sodium salt, linear alkylbenzene sulfate; and combinations
thereof.
14. The chemical mechanical planarization (CMP) polishing formulation of claim 1,
further ~~comprises~~ comprising at least one selected from the group consisting of pH
adjusting agent, biocide, dispersing agent, and wetting agent.

15. The chemical mechanical planarization (CMP) polishing formulation of claim 1, wherein the CMP polishing formulation comprises 0.001 to 0.5 wt.%, 0.005 to 0.5 wt.%, or 0.01 to 0.25 wt.% of colloidal silica having a MPS $\leq$ 30nm or $\leq$ 20nm; at least two amino acids ~~and each is~~ selected from the group consisting of aminoacetic acid (glycine), alanine, bicine, and sarcosine; hydrogen peroxide; 1,2,4-triazole or 5-amino triazole; water; and wherein the pH is from 4 to 9 or 6 to 8.

16. The chemical mechanical planarization (CMP) polishing formulation of claim 1, wherein the CMP polishing formulation comprises 0.001 to 0.5 wt.%, 0.005 to 0.5 wt.%, or 0.01 to 0.25 wt.% of colloidal silica having a MPS $\leq$ 30nm or $\leq$ 20nm; at least two amino acids ~~and each is~~ selected from the group consisting of aminoacetic acid (glycine), alanine, bicine, and sarcosine; hydrogen peroxide; 1,2,4-triazole or 5-amino triazole; 10 to 500 ppm, or 10 to 100 ppm of ethylene diamine, (2-Hydroxyethyl)trimethylammonium bicarbonate, or combinations thereof; water; and wherein the pH is from 4 to 9 or 6 to 8.

17. The chemical mechanical planarization (CMP) polishing formulation of claim 1, wherein the CMP polishing formulation comprises of 0.001 to 0.5 wt.%, 0.005 to 0.5 wt.%, or 0.01 to 0.25 wt.% of colloidal silica having a MPS $\leq$ 30nm or $\leq$ 20nm; at least two amino acids ~~and each is~~ selected from the group consisting of aminoacetic acid (glycine), alanine, bicine, and sarcosine; hydrogen peroxide; 1,2,4-triazole or 5-amino triazole; 10 to 500 ppm, or 10 to 100 ppm of ethylene diamine, (2-Hydroxyethyl)trimethylammonium bicarbonate, or combinations thereof; 0.0005 to 0.5 wt.%, 0.001 to 0.3 wt.% of a surfactant ~~containing one~~ selected from the group consisting of phenyl ethoxylate, acetylenic diol, ethoxylate-propoxylate, polyether, sulfate or sulfonate selected from the group consisting of ammonium dodecyl sulfate, sodium decyl sulfate, tetradecyl sulfate sodium salt, linear alkylbenzene sulfate, and combinations thereof; water; and wherein the pH is from 4 to 9 or 6 to 8.

18. A method of chemical mechanical planarization polishing a copper containing semiconductor substrate, comprising steps of:
providing the semiconductor substrate having a surface containing copper;
providing a polishing pad;

providing the chemical mechanical planarization (CMP) polishing formulation in any one of claims 1 to 17;

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

5 polishing the surface of the semiconductor;

wherein at least a portion of the surface containing copper is in contact with both the polishing pad and the chemical mechanical planarization (CMP) polishing formulation.

10 **19.** A system of chemical mechanical planarization polishing, comprising

a semiconductor substrate having a surface containing copper;

providing a polishing pad;

providing the chemical mechanical planarization (CMP) polishing formulation in any one of claims 1 to 17;

15 wherein at least a portion of the surface containing copper is in contact with both the polishing pad and the chemical mechanical planarization (CMP) polishing formulation.