

Claims

1. A polishing composition comprising:
 - 0.01 wt% to 30 wt% of abrasive;
 - 0.01 wt% to 30 wt% of at least one oxidizing agent;
 - 5 0.0005 wt% to 10 wt% of activator;
 - 0.1ppm to 10,000 ppm of additive;
 - pH adjusting agent; and
 - remaining being water;
 - wherein
- 10 the abrasive is selected from the group consisting of colloidal silica, fumed silica, alumina, titania, ceria, zirconia, surface modified particles selected from the group consisting of activator-containing particles, composite particles, and lattice doped and inorganic oxide particles; and combinations thereof;
- 15 the oxidizing agent is selected from the group consisting of peroxy compound 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
- 20 combinations thereof;
- the activator is selected from the group consisting of (1) inorganic oxide particle with transition metal coated onto its surface; and the transition metal is selected from the group consisting of Fe, Cu, Mn, Co, Ce, and combinations thereof;
- 25 (2)soluble catalyst selected from the group consisting of ammonium iron (III) oxalate trihydrate, iron(III) citrate tribasic monohydrate, iron(III) acetylacetonate and ethylenediamine tetraacetic acid, iron (III) sodium salt hydrate;(3) a metal compound having multiple oxidation states selected from the group consisting of Ag, Co, Cr, Cu, Fe, Mo, Mn, Nb, Ni, Os, Pd, Ru, Sn, Ti, V; and combinations thereof;
- 30 the additive is selected from the group consisting of sarcosinate, related carboxylic compound, hydrocarbon substituted sarcosinate; organic polymer and

copolymer having molecules containing ethylene oxide repeating units;
ethoxylated non-ionic surfactant; and combinations thereof;

the pH adjusting agent is selected from the group consisting of amine, ammonium
hydroxide, nitric acid, phosphoric acid, sulfuric acid, organic acid, potassium
hydroxide, and/or salt thereof, and combinations thereof; and

pH of the composition is between 2 and 10.

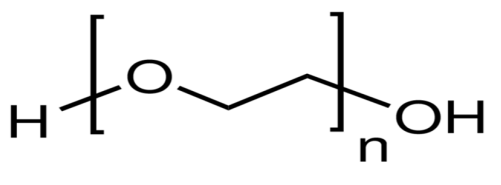
2. The polishing composition of Claim 1, wherein

the sarcosinate is selected from the group consisting of cocoyl, lauroyl, myristoyl,
oleoyl, stearyl sarcosinate, and combinations thereof;

the related carboxylic compound is selected from the group consisting of
unsaturated salt of fatty acid selected from the group consisting of myristoleic,
palmitoleic, sapienic, oleic, elaidic, vaccenic, linoleic, linoelaidic, α -linolenic,
arachidonic, eicosapentaenoic, erucic decosahexaenoic acid; and salt of
saturated fatty acid selected from the group consisting of sodium, potassium, or
ammonia salts of stearate, caprylic, capric, lauric, myristic, palmitic, stearic,
arachidic, behenic, lignoceric and cerotic acid; and combinations thereof;

the hydrocarbon substituted sarcosinate has a substituent selected from the
group consisting of an alkyl, alkenyl or alkynyl, having ranging from 1 carbon
atom for the alkyl substituent, 2 carbon atoms for the alkenyl, or 3 up to 24
carbon atoms for alkynyl substituent, wherein the number of double bonds for the
alkenyl substituent or the number of triple bonds for the alkynyl substituent is up
to 4.

3. The polishing composition of Claim 1, wherein the organic polymer and
copolymer have molecules containing ethylene oxide repeating units is
polyoxyethylene (POE), polyethylene oxide (PEO), or polyethylene glycol(PEG);
wherein the polyethylene oxide (PEO) has the general molecular structure of



wherein n refers to the total numbers of the repeating unit ranging from 4 to 113636.

- 5 4. The polishing composition of Claim 1, wherein the ethoxylated non-ionic surfactant is selected from the group consisting of alkyl phenol ethoxylate, fatty alcohol ethoxylate, fatty amine ethoxylate, propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, and combinations thereof.
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5. The polishing composition of Claim 1, wherein the additive is selected from the group consisting of polyethylene oxide (PEO), oleoyl sarcosinate, N-Lauroylsarcosinate, fatty alcohol ethoxylate, fatty amine ethoxylate, propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, and combinations thereof;
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6. The polishing composition of Claim 1 comprises colloidal silica; iron coated silica particle or ammonium iron (III) oxalate trihydrate; hydrogen peroxide; one selected from the group consisting of propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, oleoyl sarcosinate, N-Lauroylsarcosinate, and combination thereof, and the pH is between 5 and 8.
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7. The polishing composition of Claim 1 further comprises biocide ranging from 0.0001 wt % to 0.03 wt %.
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8. The polishing composition of Claim 1 further comprises at least one selected from the group consisting of surfactant; stabilizing and passivating agent; dispersion agent; chelator; film-forming anticorrosion agent; a polish enhancement agent; and combinations thereof.
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9. A system for chemical mechanical planarization, comprising:
a semiconductor substrate comprising at least one surface containing tungsten;

a polishing pad; and

a polishing composition comprising:

0.01 wt% to 30 wt% of abrasive;

0.01 wt% to 30 wt% of at least one oxidizing agent;

5 0.0005 wt% to 10 wt% of activator;

0.1ppm to 10,000 ppm of additive;

pH adjusting agent; and

remaining being water;

wherein

10 the abrasive is selected from the group consisting of colloidal silica, fumed silica, alumina, titania, ceria, zirconia, surface modified particles selected from the group consisting of activator-containing particles, composite particles, and lattice doped and inorganic oxide particles; and combinations thereof;

15 the oxidizing agent is selected from the group consisting of peroxy compound 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
20 non-per-oxy compound selected from the group consisting of ferric nitrite, KClO_4 , KBrO_4 , KMnO_4 ; and combinations thereof;

the activator is selected from the group consisting of (1) inorganic oxide particle with transition metal coated onto its surface; and the transition metal is selected from the group consisting of Fe, Cu, Mn, Co, Ce, and
25 combinations thereof; (2) soluble catalyst selected from the group consisting of ammonium iron (III) oxalate trihydrate, iron(III) citrate tribasic monohydrate, iron(III) acetylacetonate and ethylenediamine tetraacetic acid, iron (III) sodium salt hydrate; (3) a metal compound having multiple oxidation states selected from the group consisting of Ag, Co, Cr, Cu, Fe, Mo, Mn,
30 Nb, Ni, Os, Pd, Ru, Sn, Ti, V; and combinations thereof;

the additive is selected from the group consisting of sarcosinate and related carboxylic compound, hydrocarbon substituted sarcosinate; organic polymer and copolymer having molecules containing ethylene oxide repeating units; ethoxylated non-ionic surfactant; and combinations thereof;

5 the pH adjusting agent is selected from the group consisting of amine, ammonium hydroxide, nitric acid, phosphoric acid, sulfuric acid, organic acid, potassium hydroxide, and/or salt thereof, and combinations thereof; and

pH of the composition is between 2 and 10;

10 wherein the at least one surface containing tungsten is in contact with the polishing pad and the polishing composition.

10. The system of Claim 9, wherein

the sarcosinate is selected from the group consisting of cocoyl, lauroyl, myristoyl, oleoyl, stearoyl sarcosinate, and combinations thereof;

15 the related carboxylic compound is selected from the group consisting of unsaturated salt of fatty acid selected from the group consisting of myristoleic, palmitoleic, sapienic, oleic, elaidic, vaccenic, linoleic, linoelaidic, α -linolenic, arachidonic, eicosapentaenoic, erucic decosahexaenoic acid; and salt of

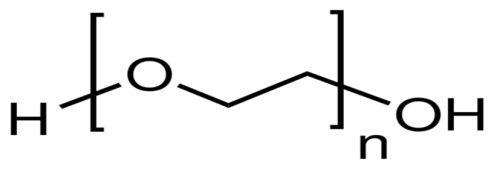
20 saturated fatty acid selected from the group consisting of sodium, potassium, or ammonia salts of stearate, caprylic, capric, lauric, myristic, palmitic, stearic, arachidic, behenic, lignoceric and cerotic acid; and combinations thereof;

the hydrocarbon substituted sarcosinate has a substituent selected from the group consisting of an alkyl, alkenyl or alkynyl, having ranging from 1 carbon

25 atom for the alkyl substituent, 2 carbon atoms for the alkenyl, or 3 up to 24 carbon atoms for alkynyl substituent, wherein the number of double bonds for the alkenyl substituent or the number of triple bonds for the alkynyl substituent is up to 4.

30 11. The system of Claim 9, wherein the organic polymer and copolymer having molecules containing ethylene oxide repeating units is polyoxyethylene (POE), polyethylene oxide (PEO), or polyethylene glycol(PEG);

wherein the polyethylene oxide (PEO) has the general molecular structure of



wherein n refers to the total numbers of the repeating unit ranging from 4 to 113636.

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12. The system of Claim 9, wherein the ethoxylated non-ionic surfactant is selected from the group consisting of alkyl phenol ethoxylate, fatty alcohol ethoxylate, fatty amine ethoxylate, propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, and combinations thereof.

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13. The system of Claim 9, wherein the polishing composition comprises colloidal silica; iron coated silica particle or ammonium iron (III) oxalate trihydrate; hydrogen peroxide; one selected from the group consisting of propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, oleoyl sarcosinate, N-Lauroylsarcosinate, and combination thereof, and the pH is between 5 and 8.

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14. The system of Claim 9, wherein the polishing composition further comprises at least one selected from the group consisting of biocide ranging from 0.0001 wt % to 0.03 wt %; surfactant; stabilizing and passivating agent; dispersion agent; chelator; film-forming anticorrosion agent; a polish enhancement agent; and combinations thereof.

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15. A polishing method for chemical mechanical planarization of a semiconductor substrate comprising at least one surface containing tungsten, comprising the steps of:

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contacting the at least one surface containing tungsten with a polishing pad;

delivering a polishing composition to the surface, the polishing composition comprising:

- 0.01 wt% to 30 wt% of abrasive;
- 0.01 wt% to 30 wt% of at least one oxidizing agent;
- 5 0.0005 wt% to 10 wt% of activator;
- 0.1ppm to 10,000 ppm of additive;
- pH adjusting agent; and
- remaining being water;
- wherein
- 10 the abrasive is selected from the group consisting of colloidal silica, fumed silica, alumina, titania, ceria, zirconia, surface modified particles selected from the group consisting of activator-containing particles, composite particles, and lattice doped and inorganic oxide particles; and combinations thereof;
- 15 the oxidizing agent is selected from the group consisting of peroxy compound 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
- 20 non-per-oxy compound selected from the group consisting of ferric nitrite, KClO_4 , KBrO_4 , KMnO_4 ; and combinations thereof;
- the activator is selected from the group consisting of (1) inorganic oxide particle with transition metal coated onto its surface; and the transition metal is selected from the group consisting of Fe, Cu, Mn, Co, Ce, and
- 25 combinations thereof; (2) soluble catalyst selected from the group consisting of ammonium iron (III) oxalate trihydrate, iron(III) citrate tribasic monohydrate, iron(III) acetylacetonate and ethylenediamine tetraacetic acid, iron (III) sodium salt hydrate; (3) a metal compound having multiple oxidation states selected from the group consisting of Ag, Co, Cr, Cu, Fe,
- 30 Mo, Mn, Nb, Ni, Os, Pd, Ru, Sn, Ti, V; and combinations thereof;

the additive is selected from the group consisting of sarcosinate and related carboxylic compound, hydrocarbon substituted sarcosinate; organic polymer and copolymer having molecules containing ethylene oxide repeating units; ethoxylated non-ionic surfactant; and combinations thereof;

the pH adjusting agent is selected from the group consisting of amine, ammonium hydroxide, nitric acid, phosphoric acid, sulfuric acid, organic acid, potassium hydroxide, and/or salt thereof, and combinations thereof; and

pH of the composition is between 2 and 10;

and

C) polishing the at least one surface containing tungsten with the polishing composition.

16. The polishing method of Claim 15, wherein

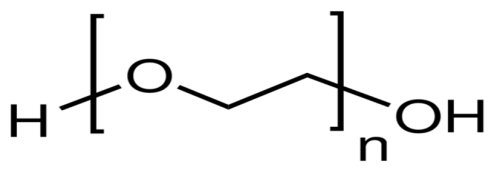
the sarcosinate is selected from the group consisting of cocoyl, lauroyl, myristoyl, oleoyl, stearoyl sarcosinate, and combinations thereof;

the related carboxylic compound is selected from the group consisting of unsaturated salt of fatty acid selected from the group consisting of myristoleic, palmitoleic, sapienic, oleic, elaidic, vaccenic, linoleic, linoelaidic, α -linolenic, arachidonic, eicosapentaenoic, erucic decosahexaenoic acid; and salt of saturated fatty acid selected from the group consisting of sodium, potassium, or ammonia salts of stearate, caprylic, capric, lauric, myristic, palmitic, stearic, arachidic, behenic, lignoceric and cerotic acid; and combinations thereof;

the hydrocarbon substituted sarcosinate has a substituent selected from the group consisting of an alkyl, alkenyl or alkynyl, having ranging from 1 carbon atom for the alkyl substituent, 2 carbon atoms for the alkenyl, or 3 up to 24 carbon atoms for alkynyl substituent, wherein the number of double bonds for the alkenyl substituent or the number of triple bonds for the alkynyl substituent is up to 4.

17. The polishing method of Claim 15, wherein the organic polymer and copolymer having molecules containing ethylene oxide repeating units is polyoxyethylene (POE), polyethylene oxide (PEO), or polyethylene glycol(PEG);

wherein the polyethylene oxide (PEO) has the general molecular structure of



wherein n refers to the total numbers of the repeating unit ranging from 4 to 113636.

18. The polishing method of Claim 15, wherein the ethoxylated non-ionic surfactant is selected from the group consisting of alkyl phenol ethoxylate, fatty alcohol ethoxylate, fatty amine ethoxylate, propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, and combinations thereof.

19. The polishing method of Claim 15, wherein the polishing composition comprises colloidal silica; iron coated silica particle or ammonium iron (III) oxalate trihydrate; hydrogen peroxide; one selected from the group consisting of propylene glycol (PPG)- ethylene glycol (PEG) block copolymer, polyether silicone surfactant, oleoyl sarcosinate, N-Lauroylsarcosinate, and combination thereof, and the pH is between 5 and 8.

20. The polishing method of Claim 19, wherein the semiconductor substrate further comprising at least one surface containing TEOS; and the ratio of the removal rates of tungsten(W_{RR}) to TEOS($TEOS_{RR}$) is greater than 60.

21. The polishing method of Claim 15, wherein the polishing composition further comprises at least one selected from the group consisting of biocide ranging from 0.0001 wt % to 0.03 wt %; surfactant; stabilizing and passivating agent; dispersion agent; chelator; film-forming anticorrosion agent; a polish enhancement agent; and combinations thereof.