

Claims

1. A barrier chemical mechanical planarization polishing composition comprising:
 - $\geq 2.4\text{wt.}\%$ of abrasive;
 - $\leq 5\text{wt.}\%$ of chemical additive;
 - corrosion inhibitor,
 - water soluble solvent;
 - second rate booster selected from the group consisting of potassium, sodium, ammonium, lithium, piperidinium nitrate salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium nitric salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium chloride salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium acetate salt and its derivatives; sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate and combinations thereof; and
 - optionally
 - surfactant selected from the group consisting of a non-ionic surfactant, an anionic surfactant, a cationic surfactant, an ampholytic surfactant, and combinations thereof;
 - pH adjusting agent;
 - oxidizing agent;
 - chelator;
 - wherein
 - the chemical additive comprising at least one polyprotic acid or its salt having more than one Pka and having Pka1 from 0.5 to 10;
 - the water soluble solvent is selected from the group consisting of DI water, a polar solvent and a mixture of DI water and polar solvent; wherein the polar solvent is selected from the group consisting of alcohol, ether, ketone, or other polar reagent; and
 - the polishing composition has a pH of 4 to 12.

2. A barrier chemical mechanical planarization polishing composition comprising:
 - $\geq 2.4\text{wt.}\%$ of abrasive;
 - $\leq 5\text{wt.}\%$ of chemical additive;
 - corrosion inhibitor,
 - water soluble solvent; and
 - optionally
 - second rate booster selected from the group consisting of potassium, sodium, ammonium, lithium, piperidinium nitrate salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium nitric salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium chloride salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium acetate salt and its derivatives; sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate and combinations thereof;
 - surfactant selected from the group consisting of a non-ionic surfactant, an anionic surfactant, a cationic surfactant, an ampholytic surfactant, and combinations thereof;
 - pH adjusting agent;
 - oxidizing agent;
 - chelator;
 - wherein
 - the chemical additive comprising at least (i) a first chemical comprising a polyprotic acid or its salt having more than one Pka and having Pka1 from 0.5 to 10; and (ii) a second chemical comprising a salt of a polyprotic acid having more than one Pka and having Pka1 from 0.5 to 10;
 - the water soluble solvent is selected from the group consisting of DI water, a polar solvent and a mixture of DI water and polar solvent; wherein the polar solvent is selected from the group consisting of alcohol, ether, ketone, or other polar reagent; and
 - the polishing composition has a pH of 4 to 12.

3. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the chemical additive comprises at least one polyprotic acid or its salt having more than one Pka and having Pka1 from 1 to 3.

4. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the abrasive is selected from the group consisting of high purity colloidal silica, nano-sized colloidal silica, alumina, ceria, germania, silica, titania, zirconia, alumina dopes colloidal silica in lattices, and combinations thereof; and the abrasive has a mean particle size of 10 nm to 300 nm.
5. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the chemical additive is selected from the group consisting of phosphonoacetic acid, its derivatives and their salts; phosphonic acid, its derivatives and their salts; phenylphosphonic acid, its derivatives and their salts; molybdenum diacid, its derivatives and their salts; oxalic acid, its derivatives and their salts; sulfurous acid, its derivative and their salts; arsenic acid, its derivatives and their salts; nitrobenzoic acid, its derivative and their salts; malonic acid, its derivative and their salts; phthalic acid, its derivative and their salts; silicic acid, its derivative and their salts; carbonic acid, its derivative and their salts; and combinations thereof.
6. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the corrosion inhibitor is selected from the group consisting of benzotriazole, 3-amino-1, 2, 4-triazole, 3, 5-diamine-1, 2, 4-triazole, and combinations thereof; and the corrosion inhibitor is present in an amount of from 0.005 wt.% to 0.5 wt.%.
7. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the composition further comprises at least one of:

the surfactant selected from the group consisting of an acetylenic diol surfactant, an alcohol ethoxylate surfactant, and a combination thereof; and the surfactant is present in an amount of from 0.001 wt. % to 1.0 wt.%;

the second rate booster selected from the group consisting of potassium, sodium, ammonium, lithium, piperidinium nitrate salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium nitric salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium chloride salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium acetate salt and its derivatives; and combinations

thereof; and the second rate booster is used in an amount ranging from 0.05 wt. % to 5 wt. %;

the pH adjusting agent selected from the group consisting of a) nitric acid, sulfuric acid, tartaric acid, succinic acid, citric acid, malic acid, malonic acid, various fatty acids, various polycarboxylic acids and combinations thereof to lower pH of the polishing composition; and (b) potassium hydroxide, sodium hydroxide, ammonia, tetraethylammonium hydroxide, ethylenediamine, piperazine, polyethyleneimine, modified polyethyleneimine, and combinations thereof to raise pH of the polishing composition; and the pH adjusting agent is used in an amount ranging from 0.001 wt.% to 1 wt.%;

the oxidizing agent selected from the group consisting of hydrogen peroxide, periodic acid, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, ammonia, amine compounds, and combinations thereof; and the oxidizing agent is used in an amount ranging from about 0.05 wt.% to about 5.0 wt.%; and

the chelator selected from the group consisting of organic acids and their salts; polymeric acids and their salts; water-soluble copolymers and their salts; copolymers and their salts containing at least two different types of acid groups selected from carboxylic acid groups; sulfonic acid groups; phosphoric acids; and pyridine acids in the same molecule of a copolymer; polyvinyl acids and their salts; polyethylene oxide; polypropylene oxide; pyridine, pyridine derivatives, bipyridine, bipyridine derivatives, and combinations thereof; and the chelator is used in an amount ranging from 0.05wt.% to about 5 wt.%.

8. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the composition comprises silicon abrasive particles having a mean particle size of 15 nm to 200 nm; 0.025 wt.% to 4 wt.% of chemical additive selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; and water; wherein the composition has a pH of 6 to 11.

9. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the composition comprises silicon abrasive particles having a mean particle size of 25 nm and 90 nm; 0.025 wt.% to 4 wt.% of chemical additive selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; second rate booster selected from the group consisting of sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; and water; wherein the composition has a pH of 7 to 11.
10. The barrier chemical mechanical planarization polishing composition of Claim 1 or 2, wherein the composition comprises silicon abrasive particles having a mean particle size of 25 nm and 90 nm; 0.025 wt.% to 4 wt.% of chemical additive having at least two selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; second rate booster selected from the group consisting of sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; and water; wherein the composition has a pH of 7 to 11.
11. A polishing method for chemical mechanical planarization of a semiconductor device comprising at least one surface having at least a barrier layer and a dielectric layer; the method comprising the steps of:
- providing the semiconductor device;
 - providing a polishing pad;
 - providing a polishing composition of Claim 1 or 2;
 - contacting the surface of the semiconductor substrate with the polishing pad and the polishing composition; and
 - polishing the least one surface;

wherein the barrier layer comprises tantalum or titanium containing films selected from the group consisting of tantalum, tantalum nitride, tantalum tungsten silicon carbide, titanium, titanium nitride, titanium-tungsten, titanium tungsten nitride, and combinations thereof; and the dielectric layer selected from the group consisting of oxide film, low-K material, and combinations thereof.

12. The polishing method of Claim 11, wherein the chemical additive comprises at least one polyprotic acid or its salt having more than one Pka and having Pka1 from 1 to 3.
13. The polishing method of Claim 11, wherein the abrasive is selected from the group consisting of high purity colloidal silica, nano-sized colloidal silica, alumina, ceria, germania, silica, titania, zirconia, alumina dopes colloidal silica in lattices, and combinations thereof; and the abrasive has a mean particle size of 10 nm to 300 nm.
14. The polishing method of Claim 11, wherein the chemical additive is selected from the group consisting of phosphonoacetic acid, its derivatives and their salts; phosphonic acid, its derivatives and their salts; phenylphosphonic acid, its derivatives and their salts; molybdenum diacid, its derivatives and their salts; oxalic acid, its derivatives and their salts; sulfurous acid, its derivative and their salts; arsenic acid, its derivatives and their salts; nitrobenzoic acid, its derivative and their salts; malonic acid, its derivative and their salts; phthalic acid, its derivative and their salts; silicic acid, its derivative and their salts; carbonic acid, its derivative and their salts; and combinations thereof.
15. The polishing method of Claim 11, wherein the corrosion inhibitor is selected from the group consisting of benzotriazole, 3-amino-1, 2, 4-triazole, 3, 5-diamine-1, 2, 4-triazole, and combinations thereof; and the corrosion inhibitor is present in an amount of from 0.005 wt.% to 0.5 wt.%.
16. The polishing method of Claim 11, wherein the polishing composition further comprises at least one of:

the surfactant selected from the group consisting of an acetylenic diol surfactant, an alcohol ethoxylate surfactant, and a combination thereof; and the surfactant is present in an amount of from 0.001 wt. % to 1.0 wt.%;

the second rate booster selected from the group consisting of potassium, sodium, ammonium, lithium, piperidinium nitrate salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium nitric salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium chloride salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium acetate salt and its derivatives; and combinations thereof; and the second rate booster is used in an amount ranging from 0.05 wt. % to 5 wt. %;

the pH adjusting agent selected from the group consisting of a) nitric acid, sulfuric acid, tartaric acid, succinic acid, citric acid, malic acid, malonic acid, various fatty acids, various polycarboxylic acids and combinations thereof to lower pH of the polishing composition; and (b) potassium hydroxide, sodium hydroxide, ammonia, tetraethylammonium hydroxide, ethylenediamine, piperazine, polyethyleneimine, modified polyethyleneimine, and combinations thereof to raise pH of the polishing composition; and the pH adjusting agent is used in an amount ranging from 0.001 wt.% to 1 wt.%;

the oxidizing agent selected from the group consisting of hydrogen peroxide, periodic acid, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, ammonia, amine compounds, and combinations thereof; and the oxidizing agent is used in an amount ranging from about 0.05 wt.% to about 5.0 wt.%; and

the chelator selected from the group consisting of organic acids and their salts; polymeric acids and their salts; water-soluble copolymers and their salts; copolymers and their salts containing at least two different types of acid groups selected from carboxylic acid groups; sulfonic acid groups; phosphoric acids; and pyridine acids in the same molecule of a copolymer; polyvinyl acids and their salts; polyethylene oxide; polypropylene oxide; pyridine, pyridine derivatives, bipyridine, bipyridine derivatives, and combinations thereof; and the chelator is used in an amount ranging from 0.05wt.% to about 5 wt.%.

17. The polishing method of Claim 11, wherein the polishing composition comprises silicon abrasive particles having a mean particle size of 15 nm to 200 nm; 0.025 wt.% to 4 wt.% of chemical additive selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; water; the polishing composition has a pH of 6 to 11; and the at least one surface comprises tantalum and tantalum nitride, and silicon dioxide.
18. The polishing method of Claim 11, wherein the polishing composition comprises silicon abrasive particles having a mean particle size of 25 nm and 90 nm; 0.025 wt.% to 4 wt.% of chemical additive selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; second rate booster selected from the group consisting of sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; water; the polishing composition has a pH of 7 to 11; and the at least one surface comprises tantalum and tantalum nitride, and silicon dioxide.
19. The polishing method of Claim 11, wherein the composition comprises silicon abrasive particles having a mean particle size of 25 nm and 90 nm; 0.025 wt.% to 4 wt.% of chemical additive having at least two selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; second rate booster selected from the group consisting of sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; and water; wherein the composition has a pH of 7 to 11.
20. A system for chemical mechanical planarization, comprising:
a semiconductor device comprising at least one surface having at least a barrier layer and a dielectric layer;

a polishing pad; and

a polishing composition of Claim 1 or 2

wherein the barrier layer comprises tantalum or titanium containing films selected from the group consisting of tantalum, tantalum nitride, tantalum tungsten silicon carbide, titanium, titanium nitride, titanium-tungsten, titanium tungsten nitride, and combinations thereof; and the dielectric layer selected from the group consisting of oxide film, low-K material, and combinations thereof; and

the at least one surface is in contact with the polishing pad and the polishing composition.

21. The system of Claim 20, wherein the chemical additive comprises at least one polyprotic acid or its salt having more than one Pka and having Pka1 from 1 to 3.

22. The system of Claim 20, wherein the abrasive is selected from the group consisting of high purity colloidal silica, nano-sized colloidal silica, alumina, ceria, germania, silica, titania, zirconia, alumina dopes colloidal silica in lattices, and combinations thereof; and the abrasive has a mean particle size of 10 nm to 300 nm.

23. The system of Claim 20, wherein the chemical additive is selected from the group consisting of phosphonoacetic acid, its derivatives and their salts; phosphonic acid, its derivatives and their salts; phenylphosphonic acid, its derivatives and their salts; molybdenum diacid, its derivatives and their salts; oxalic acid, its derivatives and their salts; sulfurous acid, its derivative and their salts; arsenic acid, its derivatives and their salts; nitrobenzoic acid, its derivative and their salts; malonic acid, its derivative and their salts; phthalic acid, its derivative and their salts; silicic acid, its derivative and their salts; carbonic acid, its derivative and their salts; and combinations thereof.

24. The system of Claim 20, wherein the corrosion inhibitor is selected from the group consisting of benzotriazole, 3-amino-1, 2, 4-triazole, 3, 5-diamine-1, 2, 4-triazole, and combinations thereof; and the corrosion inhibitor is present in an amount of from 0.005 wt. % to 0.5 wt. %.

25. The system of Claim 20, wherein the polishing composition further comprises at least one of:

the surfactant selected from the group consisting of an acetylenic diol surfactant, an alcohol ethoxylate surfactant, and a combination thereof; and the surfactant is present in an amount of from 0.001 wt. % to 1.0 wt.%;

the second rate booster selected from the group consisting of potassium, sodium, ammonium, lithium, piperidinium nitrate salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium nitric salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium chloride salt and its derivatives; potassium, sodium, ammonium, lithium, piperidinium acetate salt and its derivatives; and combinations thereof; and the second rate booster is used in an amount ranging from 0.05 wt. % to 5 wt.%;

the pH adjusting agent selected from the group consisting of a) nitric acid, sulfuric acid, tartaric acid, succinic acid, citric acid, malic acid, malonic acid, various fatty acids, various polycarboxylic acids and combinations thereof to lower pH of the polishing composition; and (b) potassium hydroxide, sodium hydroxide, ammonia, tetraethylammonium hydroxide, ethylenediamine, piperazine, polyethyleneimine, modified polyethyleneimine, and combinations thereof to raise pH of the polishing composition; and the pH adjusting agent is used in an amount ranging from 0.001 wt.% to 1 wt.%;

the oxidizing agent selected from the group consisting of hydrogen peroxide, periodic acid, potassium iodate, potassium permanganate, ammonium persulfate, ammonium molybdate, ferric nitrate, nitric acid, potassium nitrate, ammonia, amine compounds, and combinations thereof; and the oxidizing agent is used in an amount ranging from about 0.05 wt.% to about 5.0 wt.%; and

the chelator selected from the group consisting of organic acids and their salts; polymeric acids and their salts; water-soluble copolymers and their salts; copolymers and their salts containing at least two different types of acid groups selected from carboxylic acid groups; sulfonic acid groups; phosphoric acids; and pyridine acids in the same molecule of a copolymer; polyvinyl acids and their salts; polyethylene oxide; polypropylene oxide; pyridine, pyridine derivatives, bipyridine, bipyridine derivatives, and

combinations thereof; and the chelator is used in an amount ranging from 0.05wt.% to about 5 wt.%.

26. The system of Claim 20, wherein the polishing composition comprises silicon abrasive particles having a mean particle size of 15 nm to 200 nm; 0.025 wt.% to 4 wt.% of chemical additive selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; water; the polishing composition has a pH of 6 to 11; and the at least one surface comprises tantalum and tantalum nitride, and silicon dioxide.
27. The system of Claim 20, wherein the polishing composition comprises silicon abrasive particles having a mean particle size of 25 nm and 90 nm; 0.025 wt.% to 4 wt.% of chemical additive selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; second rate booster selected from the group consisting of sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; water; the polishing composition has a pH of 7 to 11; and the at least one surface comprises tantalum and tantalum nitride, and silicon dioxide.
28. The system of Claim 20, wherein the composition comprises silicon abrasive particles having a mean particle size of 25 nm and 90 nm; 0.025 wt.% to 4 wt.% of chemical additive having at least two selected from the group consisting of malonic acid, potassium sulfite, potassium molybdate, potassium silicate, potassium oxalate monohydrate, phosphonoacetic acid, and combinations thereof; second rate booster selected from the group consisting of sodium silicate, ammonium silicate, tetramethylammonium silicate, tetrabutylammonium silicate, tetraethylammonium silicate, and combinations thereof; an acetylenic diol surfactant or an alcohol ethoxylate surfactant; and water; wherein the composition has a pH of 7 to 11.