WHAT IS CLAIMED

1. A polishing composition for polishing cobalt containing material, comprising:

a) an abrasive;

b) a weak acid removal rate enhancer;

c) an azole-containing corrosion inhibitor; and

d) a pH adjuster;

wherein said removal rate enhancer, said corrosion inhibitor, and said pH adjuster each have a pKa between 1 and 18, and

wherein the pH of the composition is between 7 and 12, and

wherein the composition has less than about 100 parts per million of sulfate ions and less than about 100 parts per million of halide ions, each based on the total weight of the composition.

2. The polishing composition of claim 1, wherein said abrasive is selected from the group consisting of alumina, silica, titania, ceria, zirconia, co-formed products thereof, coated abrasives, surface modified abrasives, and mixtures thereof.

3. The polishing composition of claim 1, wherein said removal rate enhancer is selected from the group consisting of gluconic acid, lactic acid, citric acid, tartaric acid, malic acid, glycolic acid, malonic acid, formic acid, oxalic acid, acetic acid, propionic acid, peracetic acid, succinic acid, lactic acid, potassium acetate, potassium citrate, amino acetic acid, phenoxyacetic acid, bicine, phosphoric acid, diglycolic acid, glyceric acid, tricine, alanine, histidine, valine, phenylalanine, proline, glutamine, aspartic acid, glutamic acid, arginine, lysine, tyrosine, benzoic acid, salts thereof, and mixtures thereof.

4. The polishing composition of claim 1, wherein the azole-containing corrosion inhibitor is selected from the group consisting of triazole, tetrazole, benzotriazole, tolytriazole,

aminotriazole, aminobenzimidazole, pyrazole, imidazole, aminotetrazole, and mixtures thereof.

5. The polishing composition of claim 1, wherein the abrasive is present in an amount of about 0.05 to about 15 percent by weight, based on the total weight of the composition.

6. The polishing composition of claim 1, wherein said removal rate enhancer is present in amount of about 0.1 to about 20 percent by weight, based on the total weight of the composition.

7. The polishing composition of claim 1, wherein said corrosion inhibitor is present in an amount of about 0.05 to about 10 percent by weight, based on the total weight of the composition.

8. The polishing composition of claim 1, wherein said pKa of said removal rate enhancer, said corrosion inhibitor, and said pH adjuster is between 2 and 10.

9. The polishing composition of claim 8, wherein the composition has less than about 50 parts per million (ppm) of sulfate ions and less than about 50 ppm of halide ions.

10. The polishing composition of claim 1, wherein the pH adjuster is a weak acid selected from the group consisting of citric acid, tartaric acid, malic acid, glycolic acid, malonic acid, oxalic acid, acetic acid, propionic acid, peracetic acid, succinic acid, lactic acid, potassium acetate, potassium citrate, and combinations thereof.

11. The polishing composition of claim 1, wherein the corrosion potential difference (ΔE_{corr}) between Cu and Co in potentiodynamic Tafel plots is less than 30 mV ($\Delta E_{corr} < 30$ mV).

12. A point of use polishing slurry comprising the polishing composition of claim 1, wherein an oxidizer is added to the polishing composition of claim 1 at the point of use.

13. The polishing slurry of claim 12, wherein said oxidizer is hydrogen peroxide, ammonium persulfate, or a combination thereof.

14. The polishing slurry of claim 12, wherein said oxidizer is present in the point of use polishing slurry in an amount of about 0.0001 wt% to about 5 wt%, based on the total weight of the polishing slurry.

15. A polishing method, comprising:

applying a polishing composition to a substrate having cobalt on its surface; and

removing at least a portion of the cobalt from the substrate at a first rate, by bringing a pad into contact with the substrate and moving the pad in relation to the substrate,

wherein the composition comprises:

a) an abrasive;

b) a weak acid removal rate enhancer;

c) an azole-containing corrosion inhibitor; and

d) a pH adjuster;

wherein said removal rate enhancer, said corrosion inhibitor, and said pH adjuster each have a pKa between 1 and 18, and

wherein the pH of the composition is between 7 and 12, and

wherein the composition has less than about 100 parts per million of sulfate ions and less than about 100 parts per million of halide ions, each based on the total weight of the composition.

16. The method of claim 15, wherein the substrate further comprises at least one of silicon oxide, silicon nitride, metal oxide, low/ultra-low k dielectric films, and/or polysilicon on the surface, and the method further comprises:

removing said at least one of dielectric and/or metal oxide at a second rate, wherein said first rate is greater than or equal to said second rate.

17. The method of claim 16, wherein the substrate further comprises at least one other dielectric film such as silicon oxide, silicon nitride, low/ultra-low k dielectric films, and/or polysilicon on the surface, and the method further comprises:

removing said at least one of dielectric film at a third rate, wherein said first and second rates are at least 5X greater than the said third rate, and said third rate is less than 100 A/min.

18. A method for producing a semiconductor device, comprising the polishing methods of claims 15, 16, and 17.

WHAT IS CLAIMED

1. A polishing composition for polishing cobalt films, comprising:

a) an abrasive;

b) a weak acid removal rate enhancer;

c) an azole-containing corrosion inhibitor; and

d) a pH adjuster;

wherein said removal rate enhancer, said corrosion inhibitor, and said pH adjuster each have a pKa between 1 and 18, and

wherein the pH of the composition is between 7 and 12, and

wherein the composition has less than 100 parts per million of sulfate ions and less than 100 parts per million of halide ions, each based on the total weight of the composition.

2. The polishing composition of claim 1, wherein said abrasive is selected from the group consisting of alumina, silica, titania, ceria, zirconia, co-formed products thereof, coated abrasives, surface modified abrasives, and mixtures thereof.

3. The polishing composition of claim 1, wherein said removal rate enhancer is selected from the group consisting of gluconic acid, lactic acid, citric acid, tartaric acid, malic acid, glycolic acid, malonic acid, formic acid, oxalic acid, acetic acid, propionic acid, peracetic acid, succinic acid, lactic acid, potassium acetate, potassium citrate, amino acetic acid, phenoxyacetic acid, bicine, phosphoric acid, diglycolic acid, glyceric acid, tricine, alanine, histidine, valine, phenylalanine, proline, glutamine, aspartic acid, glutamic acid, arginine, lysine, tyrosine, benzoic acid, salts thereof, and mixtures thereof.

4. The polishing composition of claim 1, wherein the azole-containing corrosion inhibitor is selected from the group consisting of triazole, tetrazole, benzotriazole, tolyltriazole, aminotriazole, aminobenzimidazole, pyrazole, imidazole, aminotetrazole, and mixtures thereof.

5. The polishing composition of claim 1, wherein the abrasive is present in an amount of 0.05 to 15 percent by weight, based on the total weight of the composition.

6. The polishing composition of claim 1, wherein said removal rate enhancer is present in amount of 0.1 to 20 percent by weight, based on the total weight of the composition.

7. The polishing composition of claim 1, wherein said corrosion inhibitor is present in an amount of 0.05 to 10 percent by weight, based on the total weight of the composition.

8. The polishing composition of claim 1, wherein said pKa of said removal rate enhancer, said corrosion inhibitor, and said pH adjuster is between 2 and 10, preferably wherein the composition has less than 50 parts per million (ppm) of sulfate ions and less than 50 ppm of halide ions.

9. The polishing composition of claim 1, wherein the pH adjuster is a weak acid selected from the group consisting of citric acid, tartaric acid, malic acid, glycolic acid, malonic acid, oxalic acid, acetic acid, propionic acid, peracetic acid, succinic acid, lactic acid, potassium acetate, potassium citrate, and combinations thereof.

10. The polishing composition of claim 1, wherein the corrosion potential difference (ΔE_{corr}) between Cu and Co in potentiodynamic Tafel plots is less than 30 mV ($\Delta E_{corr} < 30$ mV).

11. A point of use polishing slurry comprising the polishing composition of claim 1, wherein an oxidizer is added to the polishing composition of claim 1 at the point of use, preferably:

wherein said oxidizer is hydrogen peroxide, ammonium persulfate, or a combination thereof, or

wherein said oxidizer is present in the point of use polishing slurry in an amount of 0.0001 wt% to 5 wt%, based on the total weight of the polishing slurry.

12. A polishing method, comprising:

applying a polishing composition to a substrate having cobalt on its surface; and

removing at least a portion of the cobalt from the substrate at a first rate, by bringing a pad into contact with the substrate and moving the pad in relation to the substrate,

wherein the composition comprises:

a) an abrasive;

b) a weak acid removal rate enhancer;

c) an azole-containing corrosion inhibitor; and

d) a pH adjuster;

wherein said removal rate enhancer, said corrosion inhibitor, and said pH adjuster each have a pKa between 1 and 18, and

wherein the pH of the composition is between 7 and 12, and

wherein the composition has less than 100 parts per million of sulfate ions and less than 100 parts per million of halide ions, each based on the total weight of the composition.

13. The method of claim 12, wherein the substrate further comprises at least one of silicon oxide, silicon nitride, metal oxide, low/ultra-low k dielectric films, and/or polysilicon on the surface, and the method further comprises:

removing said at least one of dielectric and/or metal oxide at a second rate, wherein said first rate is greater than or equal to said second rate.

14. The method of claim 13, wherein the substrate further comprises at least one other dielectric film selected from the group consisting of silicon oxide, silicon nitride, low/ultra-low k dielectric films, and polysilicon on the surface, and the method further comprises:

removing said at least one of dielectric film at a third rate, wherein said first and second rates are at least 5X greater than the said third rate, and said third rate is less than 100 A/min.

15. A method for producing a semiconductor device, comprising one of the polishing methods of claims 12, 13, or 14.