offers potentially lower resistivity than other metal / barrier layer combinations, with corresponding potential improvement in circuit performance.

[0004] Polishing compositions for aluminum damascene structures comprising alumina abrasives treated with sulfonate-containing polymers or copolymers have been described. While the sulfonate-containing polymers or copolymers are intended to confer colloidal stability to the alumina abrasives, the presence of other polishing components such as complexing agents, topography control agents, and surface treatment polymers can result in displacement of the sulfonate-containing polymers or copolymers from the alumina abrasive particles, with the result that colloidal stability of the polishing compositions is compromised. Interparticle agglomeration leading to large particles can lead to scratching and other surface defects on substrates being polished. Thus, there remains a need in the art for improved methods of polishing aluminum-containing substrates.

BRIEF SUMMARY OF THE INVENTION

[0005] A first aspect of ~~T~~the present invention provides a method of chemically-mechanically polishing a substrate, which method comprises (i) providing a substrate comprising at least one layer of aluminum, (ii) providing a polishing pad, (iii) providing a polishing composition comprising (a) an abrasive consisting of α-alumina particles, wherein the α-alumina particles are coated with a copolymer comprising at least one sulfonate monomer and at least one monomer selected from the group consisting of carboxylate monomers, phosphonate monomers, and phosphate monomers, (b) a complexing agent for aluminum, and (c) water, (iv) contacting a surface of the substrate with the polishing pad and the polishing composition, and (v) abrading at least a portion of the surface of the substrate to remove at least some aluminum from the surface of the substrate and to polish the surface of the substrate, wherein the polishing composition has a pH of about 1 to 6, and wherein the abrasive is colloidally stable in the polishing composition.

[0006] A second aspect of ~~T~~the present invention ~~also~~ provides a method of chemically-mechanically polishing a substrate, which method comprises (i) providing a substrate comprising at least one layer of aluminum, (ii) providing a polishing pad, (iii) providing a polishing composition comprising (a) an abrasive, wherein the abrasive comprises particles having a negative zeta potential in the polishing composition, (b) a complexing agent for aluminum, (c) at least one alkyldiphenyloxide disulfonate surfactant, and (~~e~~d) water, (iv) contacting a surface of the substrate with the polishing pad and the polishing composition, and (v) abrading at least a portion of the surface of the substrate to remove at least some aluminum from the surface of

the substrate and to polish the surface of the substrate, wherein the polishing composition has a pH of about 1 to 6, and wherein the abrasive is colloidally stable in the polishing composition.

[0007] ~~The invention further provides~~ There is also disclosed a chemical-mechanical polishing composition comprising (a) α-alumina particles coated with a copolymer consisting essentially of at least one sulfonate monomer and at least one acrylate monomer, (b) an organic carboxylic acid, and (c) water, wherein the polishing composition has a pH of 1 to 6, and wherein the abrasive is colloidally stable in the polishing composition.

[0008] ~~The invention additionally provides~~There is also disclosed a chemical-mechanical polishing composition comprising (a) an abrasive, wherein the abrasive comprises particles having a negative zeta potential in the polishing composition, (b) an organic carboxylic acid, (c) at least one alkyldiphenyloxide disulfonate surfactant, and (d) water, wherein the polishing composition has a pH of 1 to 6, wherein the abrasive is colloidally stable in the polishing composition, and wherein the polishing composition does not comprise a compound of the formula: $(X^2)_n$-L wherein X^2 represents tetrazole, 1,2,4-triazole, 1,2,3-triazole, or benzotriazole, and wherein L represents a linking group.

DETAILED DESCRIPTION OF THE INVENTION

[0009] The invention provides a method of chemically-mechanically polishing a substrate, which method comprises (i) providing a substrate comprising at least one layer of aluminum, (ii) providing a polishing pad, (iii) providing a polishing composition, (iv) contacting a surface of the substrate with the polishing pad and the polishing composition, and (v) abrading at least a portion of the surface of the substrate to remove at least some aluminum from the surface of the substrate and to polish the surface of the substrate. The polishing composition comprises (a) α-alumina particles coated with a copolymer comprising at least one sulfonate monomer and at least one monomer selected from the group consisting of carboxylate monomers, phosphonate monomers, and phosphate monomers, (b) a complexing agent for aluminum, and (c) water. Alternatively, the polishing composition comprises (a) an abrasive, wherein the abrasive comprises particles having a negative zeta potential in the polishing composition, (b) a complexing agent for aluminum, (c) at least one alkyldiphenyloxide disulfonate surfactant, and (c) water. In both situations, the polishing composition has a pH of 1 to 6, and the abrasive is colloidally stable in the polishing composition.

CLAIM(S):

1. A method of chemically-mechanically polishing a substrate, which method comprises:

(i) providing a substrate comprising at least one layer of aluminum,

(ii) providing a polishing pad,

(iii) providing a polishing composition comprising:

(a) an abrasive consisting of α-alumina particles, wherein the α-alumina particles are coated with a copolymer comprising at least one sulfonate monomer and at least one monomer selected from the group consisting of carboxylate monomers, phosphonate monomers, and phosphate monomers,

(b) a complexing agent for aluminum, and

(c) water,

(iv) contacting a surface of the substrate with the polishing pad and the polishing composition, and

(v) abrading at least a portion of the surface of the substrate to remove at least some aluminum from the surface of the substrate and to polish the surface of the substrate,

wherein the polishing composition has a pH of about 1 to 6, and wherein the abrasive is colloidally stable in the polishing composition.

2. The method of claim 1, wherein the copolymer comprises a combination of at least one sulfonate monomer and at least one carboxylate monomer.

3. The method of claim 2, wherein at least one carboxylate monomer comprises at least one acrylate monomer.

4. The method of claim 1, wherein the complexing agent for aluminum comprises an organic carboxylic acid.

5. The method of claim 4, wherein the organic carboxylic acid is selected from the group consisting of malonic acid, phthalic acid, lactic acid, tartaric acid, gluconic acid, citric acid, malic acid, glycolic acid, maleic acid, and combinations thereof.

6. The method of claim 1, wherein the polishing composition further comprises an agent that oxidizes aluminum.

7. The method of claim 6, wherein the agent that oxidizes aluminum is selected from the group consisting of hydrogen peroxide, organic peroxy acids, persulfate, nitrate, periodate, perbromate, bromate, ferric salts, and combinations thereof.

8. The method of claim 1, wherein the polishing composition further comprises a surfactant.

9. The method of claim 8, wherein the surfactant is an alkyldiphenyloxide disulfonate surfactant.

10. The method of claim 1, wherein the substrate further comprises at least one layer selected from the group consisting of tungsten, titanium, titanium nitride, tantalum, and tantalum nitride.

11. A method of chemically-mechanically polishing a substrate, which method comprises:

(i) providing a substrate comprising at least one layer of aluminum,

(ii) providing a polishing pad,

(iii) providing a polishing composition comprising:

(a) an abrasive, wherein the abrasive comprises particles having a negative zeta potential in the polishing composition,

(b) a complexing agent for aluminum,

(c) at least one alkyldiphenyloxide disulfonate surfactant, and

(~~e~~d) water,

(iv) contacting a surface of the substrate with the polishing pad and the polishing composition, and

(v) abrading at least a portion of the surface of the substrate to remove at least some aluminum from the surface of the substrate and to polish the surface of the substrate,

wherein the polishing composition has a pH of about 1 to 6, and wherein the abrasive is colloidally stable in the polishing composition.

12. The method of claim 11, wherein the abrasive is selected from the group consisting of wet process silica, fumed silica, and surface-coated α-alumina.

13. The method of claim 11, wherein the complexing agent for aluminum comprises an organic carboxylic acid.

14. The method of claim 13, wherein the organic carboxylic acid is selected from the group consisting of malonic acid, phthalic acid, lactic acid, tartaric acid, gluconic acid, citric acid, malic acid, glycolic acid, maleic acid, and combinations thereof.

15. The method of claim 11, wherein the polishing composition further comprises an agent that oxidizes aluminum.

16. The method of claim 15, wherein the agent that oxidizes aluminum is selected from the group consisting of hydrogen peroxide, organic peroxy acids, persulfate, nitrate, periodate, perbromate, bromate, ferric salts, and combinations thereof.

~~17. A chemical-mechanical polishing composition comprising:~~

~~(a) α-alumina particles coated with a copolymer consisting essentially of at least one sulfonate monomer and at least one acrylate monomer,~~

~~(b) an organic carboxylic acid, and~~

~~(c) water,~~

~~wherein the polishing composition has a pH of 1 to 6, and wherein the abrasive is colloidally stable in the polishing composition.~~

~~18. The composition of claim 17, wherein the copolymer comprises 50 mole% to 90 mole% of the acrylate monomer and 10 mole% to 50 mole% of the sulfonate monomer.~~

~~19. The composition of claim 17, wherein the composition further comprises an agent that oxidizes a metal.~~

~~20. The composition of claim 17, wherein the composition further comprises a surfactant.~~

~~21. The composition of claim 20, wherein the surfactant is an alkyldiphenyloxide disulfonate surfactant.~~

~~22. A chemical-mechanical polishing composition comprising:~~

~~(a) an abrasive, wherein the abrasive comprises particles having a negative zeta potential in the polishing composition,~~

~~(b) an organic carboxylic acid,~~

~~(c) at least one alkyldiphenyloxide disulfonate surfactant, and~~

~~(d) water,~~

~~wherein the polishing composition has a pH of 1 to 6, wherein the abrasive is colloidally stable in the polishing composition, and wherein the polishing composition does not comprise a compound of the formula: $(X^2)_n$-L wherein X^2 represents tetrazole, 1,2,4-triazole, 1,2,3-triazole, or benzotriazole, and wherein L represents a linking group.~~

~~23. The method of claim 22, wherein the abrasive is unmodified wet process silica or wet process silica modified with anionic functional groups.~~

~~24. The method of claim 22, wherein the abrasive comprises α-alumina particles coated with a copolymer consisting essentially of at least one sulfonate monomer and at least one acrylate monomer.~~

~~25. The method of claim 22, wherein the complexing agent for aluminum comprises an organic carboxylic acid.~~

~~26. The method of claim 25, wherein the organic carboxylic acid is selected from the group consisting of malonic acid, phthalic acid, lactic acid, tartaric acid, gluconic acid, citric acid, malic acid, glycolic acid, maleic acid, and combinations thereof.~~

~~27. The method of claim 22, wherein the polishing composition further comprises an agent that oxidizes aluminum.~~