CLAIMS

1. A chemical-mechanical polishing composition comprising:
   (a) an abrasive,
   (b) an oxidizing agent selected from the group consisting of peroxides, persulfates, ferric salts, and combinations thereof,
   (c) 25 to 400 ppm of calcium ion,
   (d) an organic carboxylic acid, and
   (e) water,
   wherein the polishing composition has a pH of 1.5 to 7.

2. The polishing composition of claim 1, wherein the abrasive is selected from the group consisting of silica and polymer-treated alumina.

3. The polishing composition of claim 2, wherein the abrasive is condensation-polymerized silica.

4. The polishing composition of claim 2, wherein the abrasive is polymer-treated alumina comprising alumina treated with a negatively-charged polymer.

5. The polishing composition of claim 4, wherein the negatively-charged polymer is poly(2-acrylamido-2-methylpropane sulfonic acid) or polystyrenesulfonic acid.

6. The polishing composition of claim 1, wherein the polishing composition comprises 0.001 wt.% to 2 wt.% of abrasive.

7. The polishing composition of claim 1, wherein the oxidizing agent is selected from the group consisting of hydrogen peroxide, ammonium persulfate, ferric nitrate, and combinations thereof.

8. The polishing composition of claim 7, wherein the polishing composition comprises 0.1 wt.% to 5 wt.% of oxidizing agent.

9. The polishing composition of claim 1, wherein the organic carboxylic acid is selected from the group consisting of citric acid, malonic acid, and tartaric acid.

10. The polishing composition of claim 1, wherein the organic acid is succinic acid.

11. The polishing composition of claim 1, wherein the polishing composition comprises 50 to 200 ppm of calcium ion.

12. The polishing composition of claim 1, wherein the polishing composition has a pH of 2 to 6.

13. A method of chemically-mechanically polishing a substrate, which method comprises:
    (i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition according to one of the preceding claims,
    (ii) moving the polishing pad relative to the substrate with the chemical-mechanical polishing composition therebetween, and
    (iii) abrading at least a portion of the substrate to polish the substrate.

14. The method of claim 13, wherein the substrate comprises at least one layer of aluminum, and at least a portion of the aluminum is removed to polish the substrate.

15. The method of claim 14, wherein the substrate further comprises at least one layer of titanium, and at least a portion of the titanium is removed to polish the substrate.

16. The method of claim 14, wherein the substrate further comprises at least one layer of a dielectric material, and at least a portion of the dielectric material is removed to polish the substrate.

17. The method of claim 13, wherein the substrate comprises at least one layer of an alloy of aluminum and copper, and at least a portion of the alloy of aluminum and copper is removed to polish the substrate.

Claims

1. A chemical-mechanical polishing composition comprising
   (a) an abrasive, wherein the abrasive is polymer-treated alumina comprising alumina treated with a negatively-charged polymer,
   (b) an oxidizing agent selected from the group consisting of peroxides, persulfates, ferric salts, and combinations thereof,
   (c) 25 to 400 ppm of calcium ion,
   (d) an organic carboxylic acid, and
   (e) water,
   wherein the polishing composition has a pH of 1.5 to 7.

2. The polishing composition of claim 1, wherein the negatively-charged polymer is poly(2-acrylamido-2-methylpropane sulfonic acid) or polystyrenesulfonic acid.

3. The polishing composition of claim 1, wherein the polishing composition comprises 0.001 wt.% to 2 wt.% of abrasive.

4. The polishing composition of claim 1, wherein the oxidizing agent is selected from the group consisting of hydrogen peroxide, ammonium persulfate, ferric nitrate, and combinations thereof.

5. The polishing composition of claim 4, wherein the polishing composition comprises 0.1 wt.% to 5 wt.% of oxidizing agent.

6. The polishing composition of claim 1, wherein the organic carboxylic acid is selected from the group consisting of citric acid, malonic acid, and tartaric acid.

7. The polishing composition of claim 1, wherein the organic acid is succinic acid.

8. The polishing composition of claim 1, wherein the polishing composition comprises 50 to 200 ppm of calcium ion.

9. The polishing composition of claim 1, wherein the polishing composition has a pH of 2 to 6.

10. A method of chemically-mechanically polishing a substrate, which method comprises:
    (i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition according to one of the preceding claims,
    (ii) moving the polishing pad relative to the substrate with the chemical-mechanical polishing composition therebetween, and
    (iii) abrading at least a portion of the substrate to polish the substrate.

11. The method of claim 10, wherein the substrate comprises at least one layer of aluminum, and at least a portion of the aluminum is removed to polish the substrate.

12. The method of claim 11, wherein the substrate further comprises at least one layer of titanium, and at least a portion of the titanium is removed to polish the substrate.

13. The method of claim 11, wherein the substrate further comprises at least one layer of a dielectric material, and at least a portion of the dielectric material is removed to polish the substrate.

14. The method of claim 10, wherein the substrate comprises at least one layer of an alloy of aluminum and copper, and at least a portion of the alloy of aluminum and copper is removed to polish the substrate.

15. **Use of a chemical-mechanical polishing composition according to any of claims 1 to 9 for polishing of a substrate comprising at least one metal layer comprising aluminum or an aluminum-containing alloy such as aluminum-copper, at least one metal layer comprising titanium, and at least one dielectric layer.**