of the wafer processing. Further, in some processes, the silicon wafers are oxidized on one side to form a protective layer of silicon oxide, and so part of the wafer edge comprises silicon oxide. While silicon polishing compositions can be used for edge polishing, typically, a higher removal rate is needed for edge polishing of silicon wafers than for surface polishing. In addition, a suitable edge polishing composition desirably exhibits a useful removal rate on silicon oxide as well as on silicon. Thus, there remains a need in the art for improved polishing compositions for silicon wafers.

BRIEF SUMMARY OF THE INVENTION

[0005] The ~~invention~~disclosure provides a polishing composition comprising (a) silica, (b) a compound or compounds that increases the removal rate of silicon, (c) a tetraalkylammonium salt, and (d) water, wherein the polishing composition has a pH of 7 to 11.

[0006] A first embodiment of the inventive chemical-mechanical polishing composition comprises a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.01 wt.% to 5 wt.% of one or more organic carboxylic acids, (c) 0.0005 wt.% to 2 wt.% of one or more aminophosphonic acids, (d) 0.01 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (e) optionally one or more bicarbonate salts, (f) optionally potassium hydroxide, and (g) water, wherein the polishing composition has a pH of 7 to 11.

[0007] A second embodiment of the inventive chemical-mechanical polishing composition comprises a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.01 wt.% to 2 wt.% of one or more polyaminocarboxylic acids, (c) 0.05 wt.% to 5 wt.% of one or more amines, (d) 0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (e) 0.001 wt.% to 1 wt.% of one or more diol compounds, (f) optionally one or more bicarbonate salts, and (g) water, wherein the polishing composition has a pH of 7 to 11.

[0008] A third embodiment of the inventive chemical-mechanical polishing composition comprises a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.01 wt.% to 2 wt.% of one or more polyaminocarboxylic acids, (c) 0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (d) 0.01 wt.% to 5 wt.% of one or more organic carboxylic acids, (e) optionally 0.1 wt.% to 5

wt.% of one or more amines, (f) optionally one or more bicarbonate salts, and (g) water, wherein the polishing composition has a pH of 7 to 11.

[0009] A fourth embodiment of the inventive chemical-mechanical polishing composition comprises a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.02 wt.% to 5 wt.% of one or more nitrogen-containing heterocyclic compounds, (c) 0.05 wt.% to 2 wt.% of one or more aminophosphonic acids, (d) 0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (e) optionally one or more bicarbonate salts, and (f) water, wherein the polishing composition has a pH of 7 to 11.

[0010] The ~~invention~~disclosure also provides a method for chemically-mechanically polishing a substrate with the inventive chemical-mechanical polishing composition.

[0011] A first embodiment of the inventive method for chemically-mechanically polishing a substrate comprises (i) contacting a substrate with a polishing pad and a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.02 wt.% to 5 wt.% of one or more organic carboxylic acids, (c) 0.02 wt.% to 2 wt.% of one or more aminophosphonic acids, (d)0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (e) optionally one or more bicarbonate salts, (f) optionally potassium hydroxide, and (g) water, wherein the polishing composition has a pH of 7 to 11, (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.

[0012] A second embodiment of the inventive method for chemically-mechanically polishing a substrate comprises (i) contacting a substrate with a polishing pad and a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.01 wt.% to 2 wt.% of one or more polyaminocarboxylic acids, (c) 0.05 wt.% to 5 wt.% of one or more amines, (d) 0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (e) 0.001 wt.% to 1 wt.% of one or more diol compounds, (f) optionally one or more bicarbonate salts, and (g) water, wherein the polishing composition has a pH of 7 to 11, (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.

[0013] A third embodiment of the inventive method for chemically-mechanically polishing a substrate comprises (i) contacting a substrate with a polishing pad and a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.01 wt.% to 2 wt.% of one or more polyaminocarboxylic acids, (c) 0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (d) 0.01 wt.% to 5 wt.% of one or more organic carboxylic acids, (e) optionally 0.1 wt.% to 5 wt.% of one or more amines, (f) optionally one or more bicarbonate salts, and (g) water, wherein the polishing composition has a pH of 7 to 11, (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.

[0014] A fourth embodiment of the inventive method for chemically-mechanically polishing a substrate comprises (i) contacting a substrate with a polishing pad and a chemical mechanical polishing composition consisting essentially of or consisting of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.02 wt.% to 5 wt.% of one or more nitrogen-containing heterocyclic compounds, (c) 0.05 wt.% to 2 wt.% of one or more aminophosphonic acids, (d)0.1 wt.% to 5 wt.% of one or more tetraalkylammonium salts, (e) optionally one or more bicarbonate salts, and (f) water, wherein the polishing composition has a pH of 7 to 11, (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.

[0015] The ~~invention~~disclosure further provides a method for polishing an edge of a silicon wafer, wherein the edge consists essentially of silicon, which method comprises (i) contacting a substrate with a polishing pad and a chemical mechanical polishing composition consisting essentially of (a) 0.5 wt.% to 20 wt.% of wet process silica, (b) 0.01 wt.% to 5 wt.% of an organic carboxylic acid, (c) 0.0005 wt.% to 2 wt.% of an aminophosphonic acid, (d) 0.01 wt.% to 5 wt.% of a tetraalkylammonium salt, (e) potassium hydroxide, (f) optionally, a bicarbonate salt, and (g) water, wherein the polishing composition has a pH of 7 to 11, (ii) moving the polishing pad relative to the edge of the silicon wafer with the chemical mechanical polishing composition therebetween, and (iii) abrading at least a portion of the edge to polish the edge of the silicon wafer.

[0016] The ~~invention~~disclosure additionally provides a method for polishing an edge of a wafer, wherein the edge has a surface consisting essentially of silicon and silicon oxide, which method comprises (i) contacting a substrate with a polishing pad and a chemical mechanical

polishing composition consisting essentially of (a) 0.5 wt.% to 20 wt.% of silica, (b) 0.01 wt.% to 5 wt.% of an organic carboxylic acid, (c) 0.0005 wt.% to 1 wt.% of an aminophosphonic acid, (d) 0.01 wt.% to 5 wt.% of a tetraalkylammonium salt, (e) optionally, a bicarbonate salt, (f) optionally, potassium hydroxide, and (g) water, wherein the polishing composition has a pH of 7 to 11, (ii) moving the polishing pad relative to the edge of the wafer with the chemical mechanical polishing composition therebetween, and (iii) abrading at least a portion of the edge to polish the edge of the wafer.

[0016a] In one aspect, there is provided a method for polishing an edge of a silicon wafer, wherein the edge consists essentially of silicon, which method comprises:

(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:

(a) about 0.5 wt. % to about 20 wt. % of wet-process silica,

(b) about 0.01 wt. % to about 5 wt. % of an organic carboxylic acid,

(c) about 0.0005 wt. % to about 2 wt. % of an aminophosphonic acid,

(d) about 0.01 wt. % to about 5 wt. % of a tetraalkylammonium salt, wherein the tetraalkylammonium salt comprises a anion selected from the group consisting of hydroxide, chloride, bromide, sulfate, and hydrogensulfate,

(e) potassium hydroxide,

(f) optionally a bicarbonate salt, and

(g) water,

wherein the polishing composition has a pH of about 8 to about 11,

(ii) moving the polishing pad relative to the edge of the silicon wafer with the chemical-mechanical polishing composition therebetween, and

(iii) abrading at least a portion of the edge to polish the edge of the silicon wafer.

[0016b] In another aspect, there is provided a method for polishing an edge of a wafer, wherein the edge has a surface consisting essentially of silicon and silicon oxide, which method comprises:

(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:

(a) about 0.5 wt. % to about 20 wt % of silica,

(b) about 0.01 wt. % to about 5 wt. % of an organic carboxylic acid,

(c) about 0.0005 wt. % to about 1 wt. % of an aminophosphonic acid,

(d) about 0.01 wt. % to about 5 wt. % of a tetraalkylammonium salt,

(e) optionally a bicarbonate salt,

(f) optionally potassium hydroxide, and

(g) water, wherein the polishing composition has a pH of about 7 to about 11,

(ii) moving the polishing pad relative to the edge of the wafer with the chemical-mechanical polishing composition therebetween, and

(iii) abrading at least a portion of the edge to polish the edge of the wafer.

BRIEF DESCRIPTION OF THE DRAWING(S)

[0017] The Figure is a schematic drawing that illustrates the surface parameter R_{max}.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The invention provides a polishing composition comprising (a) silica, (b) a compound or compounds that increases the removal rate of silicon, (c) a tetraalkylammonium salt, and (d) water, wherein the polishing composition has a pH of 7 to 11.

[0019] The silica can be any suitable form of silica such as wet-process type silica, fumed silica, or combinations thereof. For example, the silica can comprise wet-process type silica particles (e.g., condensation-polymerized or precipitated silica particles). Condensation-polymerized silica particles typically are prepared by condensing $Si(OH)_4$ to form colloidal particles, where colloidal particles are defined as having an average particle size between 1 nm and 1000 nm. Such abrasive particles can be prepared in accordance with U.S. Patent 5,230,833 or can be obtained as any of various commercially available products, such as the Akzo-Nobel Bindzil 50/80 product, the Nalco DVSTS006 product, and the Fuso PL-2 product, as well as other similar products available from DuPont, Bayer, Applied Research, Nissan Chemical, and Clariant.

[0020] The silica can comprise fumed silica particles. Fumed silica particles can be produced from volatile precursors (e.g., silicon halides) in a pyrogenic process by hydrolysis and/or oxidation of the precursors in a high temperature flame (H_2/air or H_2/CH_4/air) to produce the fumed silica. The solution containing the precursor can be sprayed into a high temperature flame using a droplet generator, and the metal oxide can then be collected. Typical droplet generators include bi-fluid atomizers, high-pressure spray nozzles, and ultrasonic atomizers. Suitable fumed silica products are commercially available from producers such as Cabot, Tokuyama, and Degussa.

CLAIM(S)

1. A method for polishing an edge of a silicon wafer, wherein the edge consists essentially of silicon, which method comprises:

(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:

(a) 0.5 wt.% to 20 wt.% of wet-process silica,

(b) 0.01 wt.% to 5 wt.% of an organic carboxylic acid,

(c) 0.0005 wt.% to 2 wt.% of an aminophosphonic acid,

(d) 0.01 wt.% to 5 wt.% of a tetraalkylammonium salt,

(e) potassium hydroxide,

(f) optionally a bicarbonate salt, and

(g) water,

wherein the polishing composition has a pH of 7 to 11,

(ii) moving the polishing pad relative to the edge of the silicon wafer with the chemical-mechanical polishing composition therebetween, and

(iii) abrading at least a portion of the edge to polish the edge of the silicon wafer.

2. The method of claim 1, wherein the polishing composition contains 0.02 wt.% to 5 wt.% of an organic carboxylic acid, 0.02 wt.% to 2 wt.% of an aminophosphonic acid, and 0.1 wt.% to 5 wt.% of a tetraalkylammonium salt.

3. The method of claim 2, wherein the polishing composition contains 5 wt.% to 20 wt.% of wet-process silica.

4. The method of claim 3, wherein the polishing composition contains 10 wt.% to 15 wt.% of wet-process silica.

5. The method of claim 2, wherein the wet-process silica has an average particle size of 4 nm to 180 nm.

6. The method of claim 5, wherein the wet-process silica has an average particle size of 20 nm to 50 nm.

7. The method of claim 2, wherein the polishing composition contains 0.1 wt.% to 2 wt.% of the organic carboxylic acid.

8. The method of claim 7, wherein the organic carboxylic acid is a hydroxycarboxylic acid.

9. The method of claim 8, wherein the organic carboxylic acid is selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof.

10. The method of claim 2, wherein the polishing composition contains 0.1 wt.% to 1 wt.% of the aminophosphonic acid.

11. The method of claim 10, wherein the aminophosphonic acid is selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino tri(methylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof.

12. The method of claim 11, wherein the aminophosphonic acid is amino tri(methylene phosphonic acid).

13. The method of claim 2, wherein the polishing composition contains a bicarbonate salt, and the bicarbonate salt is potassium bicarbonate.

14. The method of claim 2, wherein the polishing composition has a pH of 8 to 10.

15. The method of claim 1, wherein the polishing composition consists essentially of:

(a) 0.5 wt.% to 20 wt.% of wet-process silica,

(b) 0.01 wt.% to 5 wt.% of an organic carboxylic acid selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof,

(c) 0.0005 wt.% to 2 wt.% of an aminophosphonic acid selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino tri(methylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof,

(d) 0.01 wt.% to 5 wt.% of a tetraalkylammonium hydroxide,

(e) 0.05 wt.% to 2 wt.% of potassium hydroxide,

(f) 0.05 wt.% to 5 wt.% of potassium bicarbonate, and

(g) water.

16. A method for polishing an edge of a wafer, wherein the edge has a surface consisting essentially of silicon and silicon oxide, which method comprises:

(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:

(a) 0.5 wt.% to 20 wt.% of silica,

(b) 0.01 wt.% to 5 wt.% of an organic carboxylic acid,

(c) 0.0005 wt.% to 1 wt.% of an aminophosphonic acid,

(d) 0.01 wt.% to 5 wt.% of a tetraalkylammonium salt,

(e) optionally a bicarbonate salt,

(f) optionally potassium hydroxide, and

(g) water,

wherein the polishing composition has a pH of 7 to 11,

(ii) moving the polishing pad relative to the edge of the wafer with the chemical-mechanical polishing composition therebetween, and

(iii) abrading at least a portion of the edge to polish the edge of the wafer.

17. The method of claim 16, wherein the polishing composition contains 0.02 wt.% to 5 wt.% of an organic carboxylic acid, 0.02 wt.% to 2 wt.% of an aminophosphonic acid, and 0.1 wt.% to 5 wt.% of a tetraalkylammonium salt.

18. The method of claim 17, wherein the silica is fumed silica.

19. The method of claim 17, wherein the polishing composition contains 5 wt.% to 20 wt.% of silica.

20. The method of claim 19, wherein the polishing composition contains 10 wt.% to 15 wt.% of silica.

21. The method of claim 17, wherein the silica has an average particle size of 4 nm to 180 nm.

22. The method of claim 21, wherein the silica has an average particle size of 20 nm to 50 nm.

23 The method of claim 17, wherein the polishing composition contains 0.1 wt.% to 2 wt.% of the organic carboxylic acid.

24. The method of claim 23, wherein the organic carboxylic acid is a hydroxycarboxylic acid.

25. The method of claim 24, wherein the organic carboxylic acid is selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof.

26. The method of claim 17, wherein the polishing composition contains 0.1 wt.% to 1 wt.% of the aminophosphonic acid.

27. The method of claim 26, wherein the aminophosphonic acid is selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino tri(methylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof.

28. The method of claim 27, wherein the aminophosphonic acid is amino tri(methylene phosphonic acid).

29. The method of claim 17, wherein the polishing composition contains a bicarbonate salt, and the bicarbonate salt is potassium bicarbonate.

30. The method of claim 17, wherein the polishing composition contains potassium hydroxide.

31. The method of claim 17, wherein the polishing composition has a pH of 8 to 10.

32. The method of claim 16, wherein the polishing composition consists essentially of:

(a) 0.5 wt.% to 20 wt.% of wet-process silica,

(b) 0.01 wt.% to 5 wt.% of an organic carboxylic acid selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof,

(c) 0.0005 wt.% to 2 wt.% of an aminophosphonic acid selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino tri(methylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof,

(d) 0.01 wt.% to 5 wt.% of a tetraalkylammonium hydroxide,

(e) 0.05 wt.% to 2 wt.% of potassium hydroxide,

(f) 0.05 wt.% to 5 wt.% of potassium bicarbonate, and

(g) water.

CLAIMS

1. A method for polishing an edge of a silicon wafer, wherein the edge consists essentially of silicon, which method comprises:

(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:

(a) about 0.5 wt. % to about 20 wt. % of wet-process silica,

(b) about 0.01 wt. % to about 5 wt. % of an organic carboxylic acid,

(c) about 0.0005 wt. % to about 2 wt. % of an aminophosphonic acid,

(d) about 0.01 wt. % to about 5 wt. % of a tetraalkylammonium salt, wherein the tetraalkylammonium salt comprises a anion selected from the group consisting of hydroxide, chloride, bromide, sulfate, and hydrogensulfate,

(e) potassium hydroxide,

(f) optionally a bicarbonate salt, and

(g) water,

wherein the polishing composition has a pH of about 8 to about 11,

(ii) moving the polishing pad relative to the edge of the silicon wafer with the chemical-mechanical polishing composition therebetween, and

(iii) abrading at least a portion of the edge to polish the edge of the silicon wafer.

2. The method of claim 1, wherein the organic carboxylic acid is present in the polishing composition in an amount of from about 0.02 wt. % to about 5 wt. %, the aminophosphonic acid is present in the polishing composition in an amount of from about 0.02 wt. % to about 2 wt. %, and the tetraalkylammonium salt is present in the polishing composition in an amount of from about 0.1 wt. % to about 5 wt. %.

3. The method of claim 2, wherein the wet-process silica is present in the polishing composition in an amount of from about 5 wt. % to about 20 wt. %.

4. The method of claim 3, wherein the wet-process silica is present in the polishing composition in an amount of from about 10 wt. % to about 15 wt. %.

5. The method of claim 2, wherein the wet-process silica has an average particle size of about 4 nm to about 180 nm.

6. The method of claim 5, wherein the wet-process silica has an average particle size of about 20 nm to about 50 nm.

7. The method of claim 2, wherein the organic carboxylic acid is present in the polishing composition in an amount of from about 0.1 wt. % to about 2 wt. %.

8. The method of claim 7, wherein the organic carboxylic acid is a hydroxycarboxylic acid.

9. The method of claim 8, wherein the organic carboxylic acid is selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof.

10. The method of claim 2, wherein the aminophosphonic acid is present in the polishing composition in an amount of from about 0.1 wt. % to about 1 wt. %.

11. The method of claim 10, wherein the aminophosphonic acid is selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino trimethylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof.

12. The method of claim 11, wherein the aminophosphonic acid is amino trimethylene phosphonic acid).

13. The method of claim 2, wherein the polishing composition contains a bicarbonate salt, and the bicarbonate salt is potassium bicarbonate.

14. The method of claim 2, wherein the polishing composition has a pH of about 8 to about 10.

15. The method of claim 1, wherein the polishing composition consists essentially of:

(a) about 0.5 wt. % to about 20 wt. % of wet-process silica,

(b) about 0.01 wt. % to about 5 wt. % of an organic carboxylic acid selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof,

(c) about 0.0005 wt. % to about 2 wt. % of an aminophosphonic acid selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino trimethylene phosphonic acid),

diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof,

(d) about 0.01 wt. % to about 5 wt. % of a tetraalkylammonium hydroxide,

(e) about 0.05 wt. % to about 2 wt. % of potassium hydroxide,

(f) about 0.05 wt. % to about 5 wt. % of potassium bicarbonate, and

(g) water.

16. A method for polishing an edge of a wafer, wherein the edge has a surface consisting essentially of silicon and silicon oxide, which method comprises:

(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:

(a) about 0.5 wt. % to about 20 wt % of silica,

(b) about 0.01 wt. % to about 5 wt. % of an organic carboxylic acid,

(c) about 0.0005 wt. % to about 1 wt. % of an aminophosphonic acid,

(d) about 0.01 wt. % to about 5 wt. % of a tetraalkylammonium salt,

(e) optionally a bicarbonate salt,

(f) optionally potassium hydroxide, and

(g) water, wherein the polishing composition has a pH of about 7 to about 11,

(ii) moving the polishing pad relative to the edge of the wafer with the chemical-mechanical polishing composition therebetween, and

(iii) abrading at least a portion of the edge to polish the edge of the wafer.

17. The method of claim 16, wherein the organic carboxylic acid is present in the polishing composition in an amount of from about 0.02 wt. % to about 5 wt. %, the aminophosphonic acid is present in the polishing composition in an amount of from about 0.02 wt. % to about 2 wt. %, and the tetraalkylammonium salt is present in the polishing composition in an amount of from about 0.1 wt. % to about 5 wt. %.

18. The method of claim 17, wherein the silica is fumed silica.

19. The method of claim 17, wherein the silica is present in the polishing composition in an amount of from about 5 wt. % to about 20 wt. %.

20. The method of claim 19, wherein the silica is present in the polishing composition in an amount of from about 10 wt % to about 15 wt. %.

21. The method of claim 17, wherein the silica has an average particle size of about 4 nm to about 180 nm.

22. The method of claim 21, wherein the silica has an average particle size of about 20 nm to about 50 nm.

23. The method of claim 17, wherein the organic carboxylic acid is present in the polishing composition in an amount of from about 0.1 wt. % to about 2 wt. %.

24. The method of claim 23, wherein the organic carboxylic acid is a hydroxycarboxylic acid.

25. The method of claim 24, wherein the organic carboxylic acid is selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof.

26. The method of claim 17, wherein the aminophosphonic acid is present in the polishing composition in an amount of from about 0.1 wt. % to about 1 wt. %.

27. The method of claim 26, wherein the aminophosphonic acid is selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino tri(methylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof.

28. The method of claim 27, wherein the aminophosphonic acid is amino tri(methylene phosphonic acid).

29. The method of claim 17, wherein the polishing composition contains a bicarbonate salt, and the bicarbonate salt is potassium bicarbonate.

30. The method of claim 17, wherein the polishing composition contains potassium hydroxide.

31. The method of claim 17, wherein the polishing composition has a pH of about 8 to about 10.

32. The method of claim 16, wherein the polishing composition consists essentially of:

(a) about 0.5 wt. % to about 20 wt. % of wet-process silica,

(b) about 0.01 wt. % to about 5 wt. % of an organic carboxylic acid selected from the group consisting of lactic acid, oxalic acid, 2-hydroxybutyric acid, benzilic acid, and combinations thereof,

(c) about 0.0005 wt. % to about 2 wt. % of an aminophosphonic acid selected from the group consisting of ethylenediaminetetra(methylene phosphonic acid), amino trimethylene phosphonic acid), diethylenetriaminepenta(methylene phosphonic acid), and combinations thereof,

(d) about 0.01 wt. % to about 5 wt. % of a tetraalkylammonium hydroxide,

(e) about 0.05 wt. % to about 2 wt. % of potassium hydroxide,

(f) about 0.05 wt. % to about 5 wt. % of potassium bicarbonate, and

(g) water.