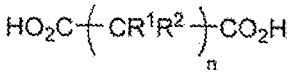
CLAIMS

1. A chemical-mechanical polishing composition consisting essentially of:

(a) silica,

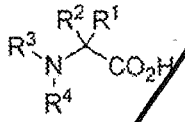
(b) one or more organic carboxylic acids, salts, or hydrates thereof selected from the group consisting of

(i) dicarboxylic acids of the formula:



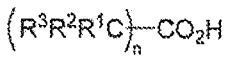
wherein n is an integer of 0-8 and each of R^1 and R^2 is independently selected from the group consisting of hydrogen, a hydroxyl group, and C_1-C_6 alkyl groups, or R^1 and R^2 together form an oxo group, and when n is 2 or more, the bonds between the CR^1R^2 groups are independently selected from the group consisting of single, double, or triple bonds;

(ii) amino acids of the formula:

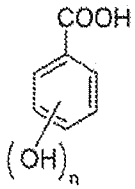


wherein each of R^1, R^2, R^3, and R^4 is independently selected from the group consisting of hydrogen, an aminoalkyl group, a carboxyalkyl group, a hydroxyalkyl group, a $-(CH_2)_n-$ group, and $-(CH{=}CH-)_n$ group connecting either R^1 or R^2 with either R^3 or R^4, wherein n is an integer of 1-6;

(iii) hydroxy acids of formula (1):



wherein n is an integer of 0-8, and each of R^1-R^3 is independently selected from the group consisting of hydrogen, alkyl, hydroxy, and hydroxyalkyl, wherein at least one of R^1-R^3 is hydroxy or hydroxyalkyl, or formula (2):



wherein n is an integer of 1-5;

(iv) carboxy substituted pyrazine compounds; and

(v) carboxy substituted triazole compounds,

(c) one or more polysaccharides selected from the group consisting of a hydroxyalkylcellulose, carrageenan, and xanthan gum,

(d) one or more bases,

(e) optionally one or more surfactants and/or polymers,

(f) optionally one or more reducing agents,

(g) optionally one or more biocides, and

(h) water,

wherein the polishing composition has an alkaline pH.

2. The polishing composition of claim 1, wherein the silica is present in an amount of 0.001 wt.% to 20 wt.% of the polishing composition.

3. The polishing composition of claim 2, wherein the silica is present in an amount of 0.05 wt.% to 10 wt.% of the polishing composition.

4. The polishing composition of claim 1, wherein the one or more organic carboxylic acids are present in a total amount of 0.0005 wt.% to 2 wt.% of the polishing composition.

5. The polishing composition of claim 1, wherein the dicarboxylic acid is selected from the group consisting of malonic acid, methyl malonic acid, dimethyl malonic acid, butyl malonic acid, maleic acid, sodium mesooxalate monohydrate, tartaric acid, malic acid, oxalic acid, and mixtures thereof.

6. The polishing composition of claim 5, wherein the dicarboxylic acid is malonic acid.

7. The polishing composition of claim 1, wherein the amino acid is selected from the group consisting of glycine, serine, glutamic acid, aspartic acid, lysine, bicine, nitrilotriacetic acid, pipecolic acid, picolinic acid, and proline.

8. The polishing composition of claim 1, wherein at least one organic carboxylic acid is a carboxy substituted pyrazine compound.

9. The polishing composition of claim 8, wherein the carboxy substituted pyrazine compound is 3-aminopyrazine-2-carboxylic acid.

10. The polishing composition of claim 1, wherein the carboxy substituted triazole compound is 3-amino-1,2,4-triazole-5-carboxylic acid.

11. The polishing composition of claim 1, wherein the aromatic hydroxy acid is selected from the group consisting of gallic acid, 4-hydroxybenzoic acid, salicylic acid, 2,4-dihydroxybenzoic acid, 2,3-dihydroxybenzoic acid, and 3,4-dihydroxybenzoic acid.

12. The polishing composition of claim 1, wherein at least one polysaccharide is hydroxyethyl cellulose.

13. The polishing composition of claim 12, wherein the average molecular weight of the hydroxyethyl cellulose is 300,000 g/mol or less.

14. The polishing composition of claim 13, wherein the average molecular weight of the hydroxyethyl cellulose is 10,000 g/mol to 100,000 g/mol.

15. The polishing composition of claim 1, wherein the pH is 8-12.

16. The polishing composition of claim 15, wherein the pH is 9-11.

17. The polishing composition of claim 1, wherein one or more surfactants and/or polymers are present in the polishing composition.

18. The polishing composition of claim 17, wherein at least one surfactant is a nonionic surfactant.

19. The polishing composition of claim 18, wherein the surfactant is an acetylenic diol surfactant or a hydrophobated polyethylene glycol.

20. The polishing composition of claim 17, wherein the one or more polymers is a polyethylene glycol polyurethane or a water soluble acrylic.

21. The polishing composition of claim 1, wherein the reducing agent is potassium metabisulfite.

22. A method of chemically-mechanically polishing a substrate comprising:

(i) contacting a substrate with a polishing pad and the chemical-mechanical polishing composition of any one of claims 1 to 21;

(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.

23. The method of claim 22, wherein the substrate comprises silicon, and a portion of the silicon is abraded to polish the substrate.

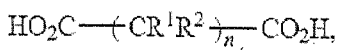
CLAIMS

1. A chemical-mechanical polishing composition consisting essentially of:

(a) silica,

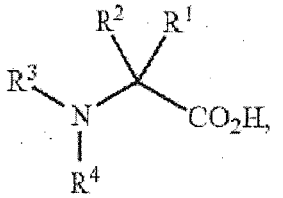
(b) one or more organic carboxylic acids, salts, or hydrates thereof selected from the group consisting of

(i) dicarboxylic acids of the formula:



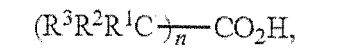
wherein n is an integer of 0-8 and each of R^1 and R^2 is independently selected from the group consisting of hydrogen, a hydroxyl group, and C_1-C_6 alkyl groups, or R^1 and R^2 together form an oxo group, and when n is 2 or more, the bonds between the CR^1R^2 groups are independently selected from the group consisting of single, double, or triple bonds;

(ii) amino acids of the formula:

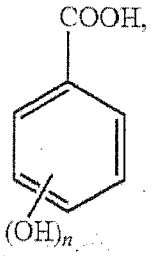


wherein each of R^1, R^2, R^3, and R^4 is independently selected from the group consisting of hydrogen, an aminoalkyl group, a carboxyalkyl group, a hydroxyalkyl group, a $-(CH_2)_n-$ group, and $-(CH=CH-)_n$ group connecting either R^1 or R^2 with either R^3 or R^4, wherein n is an integer of 1-6;

(iii) hydroxy acids of formula (1):



wherein n is an integer of 0-8, and each of R^1-R^3 is independently selected from the group consisting of hydrogen, alkyl, hydroxy, and hydroxyalkyl, wherein at least one of R^1-R^3 is hydroxy or hydroxyalkyl, or formula (2):



wherein n is an integer of 1-5;

(iv) carboxy substituted pyrazine compounds; and

(v) carboxy substituted triazole compounds,

(c) one or more polysaccharides selected from the group consisting of a hydroxyalkylcellulose, carrageenan, and xanthan gum,
(d) one or more bases,
(e) optionally one or more surfactants and/or polymers,
(f) optionally one or more reducing agents,
(g) optionally one or more biocides, and
(h) water, wherein the polishing composition has an alkaline pH.

2. The polishing composition of claim 1, wherein the silica is present in an amount of about 0.001 wt. % to about 20 wt. % of the polishing composition.

3. The polishing composition of claim 2, wherein the silica is present in an amount of about 0.05 wt. % to about 10 wt. % of the polishing composition.

4. The polishing composition of claim 1, wherein the silica is wet-process silica.

5. The polishing composition of claim 1, wherein the one or more organic carboxylic acids are present in a total amount of about 0.0005 wt. % to about 2 wt. % of the polishing composition.

6. The polishing composition of claim 1, wherein the dicarboxylic acid is selected from the group consisting of malonic acid, methyl malonic acid, dimethyl malonic acid, butyl malonic acid, maleic acid, sodium mesooxalate monohydrate, tartaric acid, malic acid, oxalic acid, and mixtures thereof.

7. The polishing composition of claim 6, wherein the dicarboxylic acid is malonic acid.

8. The polishing composition of claim 1, wherein the amino acid is selected from the group consisting of glycine, serine, glutamic acid, aspartic acid, lysine, bicine, nitrilotriacetic acid, pipecolic acid, picolinic acid, and proline.

9. The polishing composition of claim 1, wherein at least one organic carboxylic acid is a carboxy substituted pyrazine compound.

10. The polishing composition of claim 9, wherein the carboxy substituted pyrazine compound is 3-aminopyrazine-2-carboxylic acid.

11. The polishing composition of claim 1, wherein the carboxy substituted triazole compound is 3-amino-1,2,4-triazole-5-carboxylic acid.

12. The polishing composition of claim 1, wherein the hydroxy acid is selected from the group consisting of aliphatic hydroxy acids and aromatic hydroxy acids.

13. The polishing composition of claim 12, wherein the aliphatic hydroxy acid is selected from the group consisting of lactic acid, glycolic acid, 2-hydroxybutyric acid, and dimethylolpropionic acid.

14. The polishing composition of claim 1, wherein the aromatic hydroxy acid is selected from the group consisting of gallic acid, 4-hydroxybenzoic acid, salicylic acid, 2,4-dihydroxybenzoic acid, 2,3-dihydroxybenzoic acid, and 3,4-dihydroxybenzoic acid.

15. The polishing composition of claim 1, wherein at least one polysaccharide is a hydroxyalkyl cellulose.

16. The polishing composition of claim 15, wherein the hydroxyalkyl cellulose is hydroxyethyl cellulose.

17. The polishing composition of claim 16, wherein the average molecular weight of the hydroxyethyl cellulose is about 300,000 g/mol or less.

18. The polishing composition of claim 17, wherein the average molecular weight of the hydroxyethyl cellulose is about 10,000 g/mol to about 100,000 g/mol.

19. The polishing composition of claim 1, wherein at least one base is selected from the group consisting of an alkali metal hydroxide, an alkali metal carbonate, an alkali metal bicarbonate, and a borate.

20. The polishing composition of claim 19, wherein at least one base is selected from the group consisting of potassium hydroxide, potassium carbonate, and potassium bicarbonate.

21. The polishing composition of claim 1, wherein the pH is about 8-12.

22. The polishing composition of claim 21, wherein the pH is about 9-11.

23. The polishing composition of claim 1, wherein one or more surfactants and/or polymers are present in the polishing composition.

24. The polishing composition of claim 23, wherein at least one surfactant is a nonionic surfactant.

25. The polishing composition of claim 24, wherein the surfactant is an acetylenic diol surfactant or a hydrophobated polyethylene glycol.

26. The polishing composition of claim 23, wherein the one or more polymers is a polyethylene glycol polyurethane or a water soluble acrylic.

27. The polishing composition of claim 1, wherein the reducing agent is potassium metabisulfite.

28. The polishing composition of any one of claims 1-27, wherein one or more biocides are present in the polishing composition.

29. The polishing composition of claim 28, wherein the biocide is an isothiazolinone biocide.

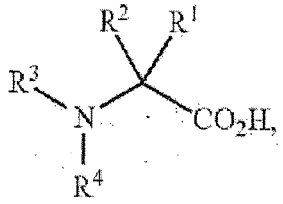
30. A method of chemically-mechanically polishing a substrate comprising:
(i) contacting a substrate with a polishing pad and a chemical-mechanical polishing composition consisting essentially of:
(a) silica,
(b) one or more organic carboxylic acids or salts thereof selected from the group consisting of

(i) dicarboxylic acids of the formula:



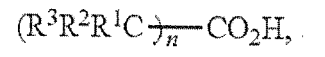
wherein n is an integer of 0-8 and each of R^1 and R^2 is independently selected from the group consisting of hydrogen, a hydroxyl group, and C_1-C_6 alkyl groups, or R^1 and R^2 together form an oxo group; and when n is 2 or more, the bonds between the CR^1R^2 groups are independently selected from the group consisting of single, double, or triple bonds;

(ii) amino acids of the formula:

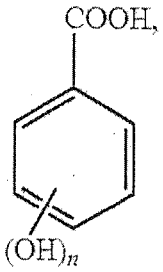


wherein each of R^1, R^2, R^3, and R^4 is independently selected from the group consisting of hydrogen, an aminoalkyl group, a carboxyalkyl group, a hydroxyalkyl group, a $-(CH_2)_n-$ group, a $-(CH=CH-)_n$ group connecting either R^1 or R^2 with either R^3 or R^4, wherein n is an integer of 1-6;

(iii) hydroxy acids of the formula (1):



wherein n is an integer of 0-8, and each of R^1-R^3 is independently selected from the group consisting of hydrogen, alkyl, hydroxy, and hydroxyalkyl, wherein at least one of R^1-R^3 is hydroxy or hydroxyalkyl, or the formula (2):



wherein n is an integer of 1-5;

(iv) carboxy substituted pyrazine compounds; and

(v) carboxy substituted triazole compounds,

(c) one or more polysaccharides selected from the group consisting of a hydroxyalkylcellulose, carrageenan, and xanthan gum,

(d) one or more bases,

(e) optionally one or more surfactants and/or polymers,

(f) optionally one or more reducing agents,

(g) optionally one or more biocides, and

(h) water, wherein the polishing composition has an alkaline pH,

(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.

31. The method of claim 30, wherein the silica is present in an amount of about 0.001 wt. % to about 20 wt. % of the polishing composition.

32. The method of claim 31, wherein the silica is present in an amount of about 0.05 wt. % to about 10 wt. % of the polishing composition.

33. The method of claim 30, wherein the silica is wet-process silica.

34. The method of claim 30, wherein the one or more organic carboxylic acids are present in a total amount of about 0.0005 wt. % to about 2 wt. % of the polishing composition.

35. The method of claim 30, wherein the dicarboxylic acid is selected from the group consisting of malonic acid, methyl malonic acid, dimethyl malonic acid, butyl malonic acid, maleic acid, sodium mesooxalate monohydrate, tartaric acid, malic acid, oxalic acid, and mixtures thereof.

36. The method of claim 35, wherein the dicarboxylic acid is malonic acid.

37. The method of claim 30, wherein the amino acid is selected from the group consisting glycine, serine, glutamic acid, aspartic acid, lysine, bicine, nitrilotriacetic acid, pipecolic acid, picolinic acid, and proline.

38. The method of claim 30, wherein at least one organic carboxylic acid is a carboxy substituted pyrazine compound.

39. The method of claim 38, wherein the amino-carboxy substituted pyrazine compound is 3-aminopyrazine-2-carboxylic acid.

40. The method of claim 30, wherein the carboxy substituted triazole compound is 3-amino-1,2,4-triazole-5-carboxylic acid.

41. The method of claim 30, wherein the hydroxy acid is selected from the group consisting of aliphatic hydroxy acids and aromatic hydroxy acids.

42. The method of claim 41, wherein the aliphatic hydroxy acid is selected from the group consisting of lactic acid, glycolic acid, 2-hydroxybutyric acid, and dimethylolpropionic acid.

43. The method of claim 41, wherein the aromatic hydroxy acid is selected from the group consisting of gallic acid, 4-hydroxybenzoic acid, salicylic acid, 2,4-dihydroxybenzoic acid, 2,3-dihydroxybenzoic acid, and 3,4-dihydroxybenzoic acid.

44. The method of claim 30, wherein at least one polysaccharide is a hydroxyalkyl cellulose.

45. The method of claim 44, wherein the hydroxyalkyl cellulose is hydroxyethyl cellulose.

46. The method of claim 45, wherein the average molecular weight of the hydroxyethyl cellulose is about 300,000 g/mol or less.

47. The method of claim 46, wherein the average molecular weight of the hydroxyethyl cellulose is about 10,000 g/mol to about 100,000 g/mol.

48. The method of any one of claim 30, wherein at least one base is selected from the group consisting of an alkali metal hydroxide, an alkali metal carbonate, an alkali metal bicarbonate, and a borate.

49. The method of claim 48, wherein at least one base is selected from the group consisting of potassium hydroxide, potassium carbonate, and potassium bicarbonate.

50. The method of claim 30, wherein the pH is about 8-12.

51. The method of claim 50, wherein the pH is about 9-11.

52. The method of claim 30, wherein one or more surfactants and/or polymers are present in the polishing composition.

53. The method of claim 30, wherein at least one surfactant is a nonionic surfactant.

54. The method of claim 53, wherein the surfactant is an acetylenic diol surfactant or a hydrophobated polyethylene glycol.

55. The method of claim 30, wherein the one or more polymers is a polyethylene glycol polyurethane or a water soluble acrylic.

56. The method of claim 30, wherein the reducing agent is potassium metabisulfite.

57. The method of claim 30, wherein the substrate comprises silicon, and a portion of the silicon is abraded to polish the substrate.

58. The method of claim 30, wherein one or more biocides are present in the polishing composition.

59. The polishing composition of claim 58, wherein the biocide is an isothiazolinone biocide.