Claims

1. A chemical mechanical polishing composition comprising:

ceria-coated inorganic oxide particles;

nitrogen containing organic aromatic or pyridine ring molecule with one carboxylic acid group, one carboxylate salt group, or one carboxylate ester group;

non-ionic organic molecule with multi hydroxyl functional groups;

water soluble solvent; and

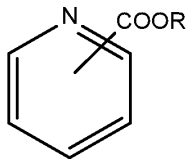
optionally

biocide; and

pH adjuster;

wherein

the nitrogen containing organic aromatic or pyridine ring molecule with one carboxylic acid group, one carboxylate salt group, or one carboxylate ester group has a general molecular structure of:



wherein R can be hydrogen atom, a positive metal ion, or an alkyl group C_nH_{2n+1}, n is from 1 to 12, preferably 1 to 6, and more preferably 1 to 3;

and

the composition has a pH of 2 to 12, preferably 3 to 10, and more preferably 4 to 9, and most preferably 4.5 to 7.5.

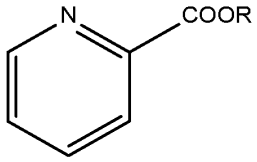
2. The chemical mechanical polishing composition of Claim 1, wherein the ceria-coated inorganic oxide particles are selected from the group consisting of ceria-coated colloidal silica, ceria-coated high purity colloidal silica, ceria-coated alumina, ceria-coated titania, ceria-coated zirconia particles and combinations thereof; wherein the particles range from 0.01 wt.% to 20 wt.%; preferably from 0.05 wt.% to 10 wt.%, and more preferably from 0.1 wt.% to 5 wt.%.

3. The chemical mechanical polishing composition of Claim 1, wherein the water soluble solvent is selected from the group consisting of deionized (DI) water, distilled water, and alcoholic organic solvents.

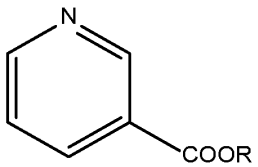
4. The chemical mechanical polishing of Claim 1, wherein thenitrogen containing organic aromatic or pyridine ring molecule with one carboxylic acid group, one carboxylate salt group, or one carboxylate ester group ranges from 0.0001 wt.% to 2.0% wt.%, 0.0005 wt.% to 1.0 wt.%, or 0.0005 wt.% to 0.5 wt.%.

5. The chemical mechanical polishing of Claim 1, wherein the organic molecular with multi hydroxyl functional groups ranges from 0.0001 wt.% to 2.0% wt.%, 0.001 wt.% to 1.0 wt.%, or 0.005 wt.% to 0.75 wt.%.

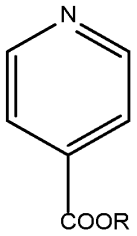
6. The chemical mechanical polishing composition of Claim 1, wherein the -COOR group in the nitrogen containing organic aromatic or pyridine ring molecule can be attached to carbon atom positioned at -2, -3, or 4 in the ring as shown below:



(1),

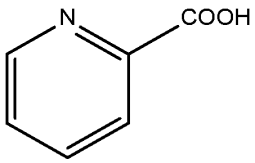


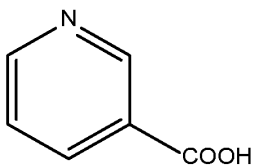
(2),

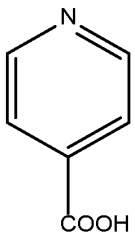


and (3).

7. The chemical mechanical polishing composition of Claim 1, wherein R in the -COOR group of the nitrogen containing organic aromatic or pyridine ring molecule is hydrogen atom, and the -COOH group can be attached to carbon atom positioned at -2, -3, or 4 in the ring as shown below:

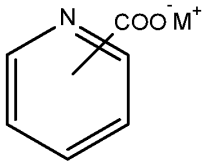






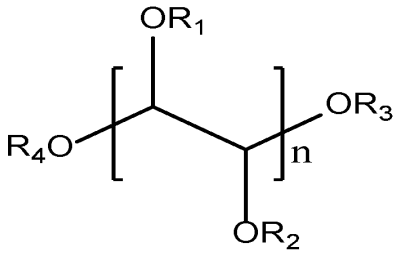
2-Picolinic Acid, 3-Pyridinrcarboxylic Acid, and 4-Pyridinrcarboxylic Acid.

8. The chemical mechanical polishing composition of Claim 1, wherein R in the -COOR group of the nitrogen containing organic aromatic or pyridine ring molecule is a positive metal ion M^+ selected from the group consisting of sodium, potassium, and ammonium ion;



9. The chemical mechanical polishing composition of Claim 1, wherein R in the -COOR group of the nitrogen containing organic aromatic or pyridine ring molecule is an alkyl group C_nH_{2n+1}, n is from 1 to 12, preferably 1 to 6, and more preferably 1 to 3; and the nitrogen containing organic aromatic or pyridine ring molecule is a pyridine carboxylate ester.

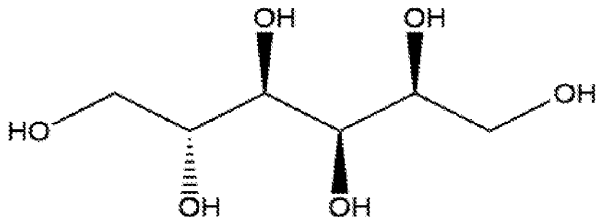
10. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic molecule with multi hydroxyl functional groups has a general molecular structure of:



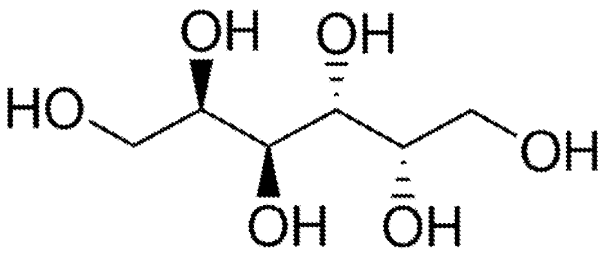
wherein n is selected from 1 to 5,000, preferably from 2 to 12, more preferably from 3 to 6;

R1, R2, R3, and R4 of R groups can be the same or different atoms or functional groups; and independently selected from the group consisting of hydrogen, an alkyl group C_nH_{2n+1}, n is from 1 to 12, preferably 1 to 6, and more preferably 1 to 3; alkoxy, organic group with one or more hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic acid ester, organic amine groups, and combinations thereof; wherein, at least two or more, preferably four or more of R groups are all hydrogen atoms.

11. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic molecule with multi hydroxyl functional groups is selected from the group consisting of



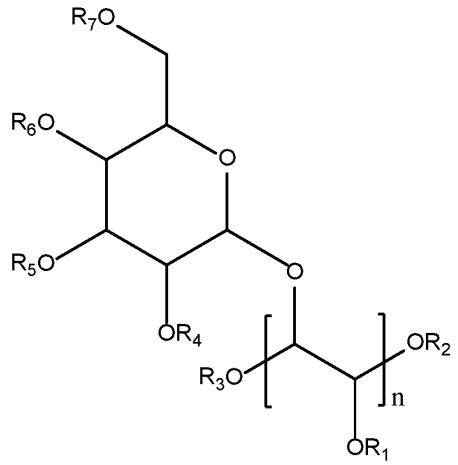
D-sorbitol;



Dulcitol;

and combinations thereof.

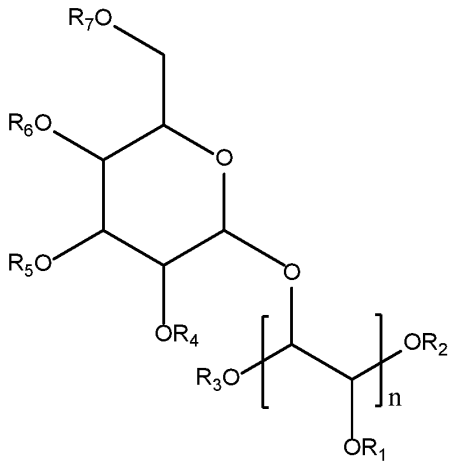
12. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic molecule with multi hydroxyl functional groups has a general molecular structure of:



wherein n is selected from 1 to 5,000, preferably from 1 to 100, more preferably from 1 to 12, and most preferably from 2 to 6;

R1, R2, R3, R4, R5, R6, and R7 of R groups can be the same or different atoms or functional groups; and independently selected from the group consisting of hydrogen, an alkyl group C_nH_{2n+1}, n is from 1 to 12, preferably 1 to 6, and more preferably 1 to 3; alkoxy, organic group with one or more hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic acid ester, organic amine groups, and combinations thereof; wherein, at least two or more, preferably four or more, more preferably six or more of R groups are hydrogen atoms.

13. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic molecule with multi hydroxyl functional groups has a general molecular structure of:

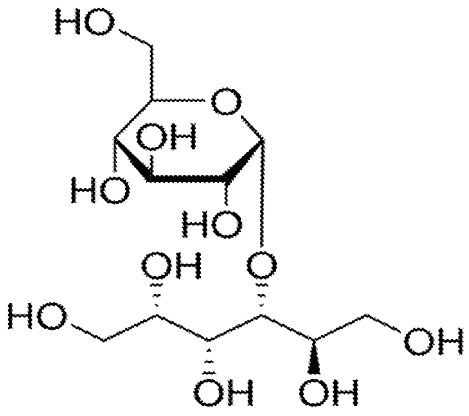


wherein

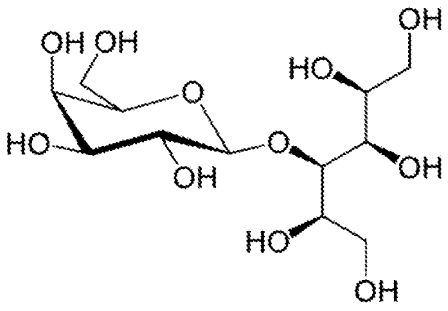
n is selected from 1 to 5,000, preferably from 1 to 100, more preferably from 1 to 12, and most preferably from 2 to 6; and

R1, R2, R3, R4, R5, R6, and R7 are all hydrogen atoms.

14. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic molecule with multi hydroxyl functional groups is selected from the group consisting of



Maltitol;



Lactitol;

and combinations thereof.

15. The chemical mechanical polishing composition of Claim 1, wherein the composition comprises ceria-coated colloidal silica particles; the non-ionic organic molecule with multi hydroxyl functional groups; the pyridine ring molecule with one carboxylic acid, carboxylate salt, or carboxylate ester connected to carbon atom positioned at -2, -3, or -4 in the pyridine ring; and water.

16. The chemical mechanical polishing composition of Claim 1, wherein the composition comprises ceria-coated colloidal silica particles; at least one selected from the group consisting of lactitol, Maltitol, Dulcitol, and D-sorbitol; the pyridine ring molecule with one carboxylic acid, carboxylate salt, or carboxylate ester connected to carbon atom positioned at -2, -3, or -4 in the pyridine ring; and water.

17. The chemical mechanical polishing composition of Claim 1, wherein the composition comprises ceria-coated colloidal silica particles; at least one selected from the group consisting of lactitol, Maltitol, Dulcitol, and D-sorbitol; and at least one selected from the group consisting of 2-Picolinic Acid, 3-Pyridinrcarboxylic Acid, and 4-Pyridinrcarboxylic Acid.

18. The chemical mechanical polishing composition of Claim 1, wherein the composition comprises ceria-coated colloidal silica particles; at least one selected from the group consisting of lactitol, Maltitol, Dulcitol, and D-sorbitol; and 2-Picolinic Acid.

19. The chemical mechanical polishing composition of any of Claims 1, wherein the composition further comprises from 0.0001 wt.% to 0.05 wt.%; preferably from 0.0005 wt.% to 0.025 wt.%, and more preferably from 0.001 wt.% to 0.01 wt.% of the biocide having active ingredients of 5-chloro-2-methyl-4-isothiazolin-3-one and 2-methyl-4-isothiazolin-3-one.

20. The chemical mechanical polishing composition of Claim 1, wherein the composition further comprises from 0 wt.% to 1 wt.%; preferably 0.01 wt.% to 0.5 wt.%; more preferably 0.1 wt.% to 0.25 wt.% of the pH adjuster selected from the group consisting of nitric acid, hydrochloric acid, sulfuric acid, phosphoric acid, other inorganic or organic acids, and mixtures thereof for acidic pH conditions; or selected from the group consisting of sodium hydride, potassium hydroxide, ammonium hydroxide, tetraalkyl ammonium hydroxide, organic quaternary ammonium hydroxide compounds, organic amines, and combinations thereof for alkaline pH conditions.

21. A method of chemical mechanical polishing (CMP) a semiconductor substrate having at least one surface comprising a silicon oxide film, comprising

providing the semiconductor substrate;

providing a polishing pad;

providing the chemical mechanical polishing composition in any of claims 1 to 20;

contacting the at least one surface of the semiconductor substrate with the polishing pad and the chemical mechanical polishing composition; and

polishing the at least one surface comprising the silicon oxide film.

22. The method of claim 21; wherein the silicon oxide film is selected from the group consisting of Chemical vapor deposition (CVD), Plasma Enhance CVD (PECVD), High Density Deposition CVD(HDP), or spin on silicon oxide film.

23. The method of claim 21; wherein the silicon oxide film is SiO_2 film.

24. The method of claim 21; wherein the semiconductor substrate further having at least one surface comprising a silicon nitridefilm; and removal selectivity of silicon oxide:

silicon nitride is greater than 10, preferably greater than 30, and more preferably greater than 50.

25. A system of chemical mechanical polishing (CMP) a semiconductor substrate having at least one surface comprising a silicon oxide film, comprising
    a. the semiconductor substrate;
    b. the chemical mechanical polishing composition in any one of Claim 1 to 20;
    c. a polishing pad;

    wherein the at least one surface comprising the silicon oxide film is in contact with the polishing pad and the chemical mechanical polishing composition.

26. The system of claim 25; wherein the silicon oxide film is selected from the group consisting of Chemical vapor deposition (CVD), Plasma Enhance CVD (PECVD), High Density Deposition CVD(HDP), or spin on silicon oxide film.

27. The system of claim 25; wherein the silicon oxide film is SiO_2 film.

28. The system of claim 25; wherein the the semiconductor substrate further having at least one surface comprising a silicon nitride film, wherein the at least one surface comprising a silicon nitride film is in contact with the polishing pad and the chemical mechanical polishing composition; and removal selectivity of silicon oxide: silicon nitride is greater than 10, preferably greater than 30, and more preferably greater than 50;when the at least surface comprising a silicon oxide film and the at least one surface comprising a silicon nitride film are polished with the polishing pad and the chemical mechanical polishing composition.