

TITLE OF THE INVENTION:

Chemical Mechanical Planarization for
Shallow Trench Isolation

CROSS REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/485,671 filed on February 17, 2023, which is incorporated herein by reference as if fully set forth.

BACKGROUND OF THE INVENTION

[0002] This invention relates to the STI CMP chemical polishing compositions and chemical mechanical planarization (CMP) for Shallow Trench Isolation (STI) process.

[0003] In the fabrication of microelectronics devices, an important step involved is polishing, especially surfaces for chemical-mechanical polishing for the purpose of recovering a selected material and/or planarizing the structure.

[0004] For example, a SiN layer is deposited under a SiO₂ layer to serve as a polish stop. The role of such polish stop is particularly important in Shallow Trench Isolation (STI) structures. Selectivity is characteristically expressed as the ratio of the oxide polish rate to the nitride polish rate. An example is an increased polishing selectivity ratio of silicon dioxide (SiO₂) as compared to silicon nitride (SiN).

[0005] In the global planarization of patterned STI structures, reducing erosions on various density features of the polished STI patterned wafers is a key factor to be considered. The lower the erosion on various density features of the polished STI patterned wafers will prevent electrical current leaking between adjacent transistors. Non-uniform trench oxide loss across die (within Die) will affect transistor performance and device fabrication yields. Severe erosions on various density features of the polished STI patterned wafers will cause poor isolation of transistor resulting in device failure. Therefore, it is important to reduce erosions on various density features of the polished STI patterned wafers.

[0006] As Semiconductor Fabs move to more advanced node chip fabrications, to further reduce SiN film removal rates, increase SiO₂: SiN selectivity and reduce erosions on various density features of the polished STI patterned wafers become more important to increase the chip fabrication yields.

[0007] A published US patent application 2020/0048551 A1 disclosed polishing compositions comprising ceria coated silica particles and organic acids having one selected from the group consisting of sulfonic acid group, phosphonic acid group, pyridine compound, and combinations thereof, with pH between 5 and 10 and electrical conductivity between 0.2 and 10 milli Siemens per centimeter provide very high silicon oxide removal rates for advanced semiconductor device manufacturing.

[0008] A published US patent application 2020/0071566 A1 disclosed a slurry composition for a chemical mechanical polishing (CMP) process includes about 0.1 % by weight to about 10 % by weight of polishing particles, about 0.001 % by weight to about 1 % by weight of an amine compound, about 0.001 % by weight to about 1 % by weight of a first cationic compound that is amino acid, about 0.001 % by weight to about 1 % by weight of a second cationic compound that is organic acid, and about 1 % by weight to about 5 % by weight of polyhydric alcohol including at least two hydroxyl groups.

[0009] A published US patent application 2021/0130651 A1 disclosed the chemical mechanical polishing (CMP) slurry compositions, such as CMP slurry compositions for polishing an indium tin oxide (ITO) layer, along with methods of fabricating a semiconductor device using such a CMP slurry composition. The CMP slurry composition can include a polishing particle, a dispersing agent, an auxiliary oxidizing agent, and a sugar alcohol compound.

[0010] A published US patent applications 2020/0002607 A1 and 2020/0002608 A1 disclosed the Chemical mechanical planarization (CMP) polishing compositions, methods and systems are provided to reduce oxide trench dishing and improve over-polishing window stability. High and tunable silicon oxide removal rates, low silicon nitride removal rates, and tunable SiO₂: SiN selectivity are also provided. The compositions use a unique combination of abrasives, such as ceria coated silica particles; and the chemical additives, such as maltitol, lactitol, maltotritol, ribitol, D-sorbitol, mannitol, dulcitol, iditol, D-(-)-Fructose, sorbitan, sucrose, ribose, Inositol, glucose, D-arabinose, L-arabinose, D-mannose, L-mannose, meso-erythritol, beta-lactose, arabinose, or combinations thereof as oxide trench dishing reducing additives.

[0011] However, those prior disclosed Shallow Trench Isolation (STI) polishing compositions did not address the importance of reducing various sized feature erosions on the polished patterned wafers along with the high oxide vs nitride selectivity.

[0012] It should be readily apparent from the foregoing that there remains a need within the art for compositions, methods and systems of STI chemical mechanical polishing that can afford the further reduced SiN removal rates, further increased SiO₂ SiN selectivity, and more effectively reduced erosions on various density features of the polished STI patterned wafers in a STI chemical and mechanical polishing (CMP) process, in addition to high removal rate of silicon dioxide.

BRIEF SUMMARY OF THE INVENTION

[0013] The present invention provides the STI polishing compositions which provide the further reduced SiN removal rate, further increased SiO₂: SiN selectivity, and more importantly the effectively reduced erosions on the low-density and narrow sized features on the polished patterned wafers for Shallow Trench Isolation (STI) CMP applications at wide pH range including acidic, neutral and alkaline pH conditions.

[0014] The disclosed chemical mechanical polishing (CMP) composition for Shallow Trench Isolation (STI) CMP applications have a unique combination of using ceria-coated inorganic oxide particles as abrasives; non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecule; and a chemical additive having at least one or bi-carboxylic functional group or at least two carboxylic functional groups, and at least two hydroxyl groups on the same molecule.

[0015] The chemical additive having at least one preferably at least two carboxylic functional groups or bi-carboxylic functional group and at least two hydroxyl groups on the same molecules functions to achieve the STI CMP performances with further reduced SiN removal rates, further increased SiO₂: SiN removal selectivity, and importantly the effectively reduced erosions on all sized features of polished STI patterned wafers.

[0016] In one aspect, there is provided a STI CMP polishing composition comprises, consist essentially of, or consists of:

ceria-coated inorganic oxide particles;

a non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules;

a chemical additive having at least one preferably at least two carboxylic functional groups (or di-carboxylic functional group), and at least two hydroxyl groups on the same molecules;

a water-soluble solvent;

and optionally

biocide; and

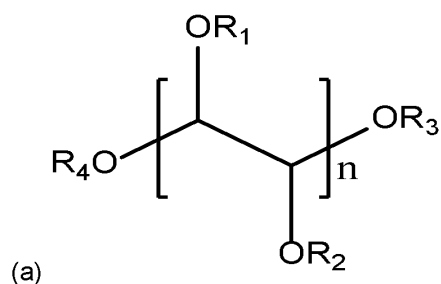
pH adjuster;

wherein the composition has a pH of 2 to 12, preferably 3 to 11, more preferably 4 to 10, and most preferably 5 to 9.

[0017] The ceria-coated inorganic oxide particles include, but are not limited to, ceria-coated silica, ceria-coated colloidal silica, ceria-coated high purity colloidal silica, ceria-coated alumina, ceria-coated titania, ceria-coated zirconia, or any other ceria-coated inorganic oxide particles.

[0018] The water-soluble solvent includes but is not limited to deionized (DI) water, distilled water, and alcoholic organic solvents.

[0019] The non-ionic organic alcohol compounds with multi hydroxyl groups on the same molecules have a general molecular structure (a) as shown below:

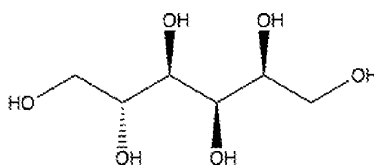


[0020] In the general molecular structures for the non-ionic organic alcohol compound, n is selected from 2 to 5,000, the preferred n is from 3 to 12, the more preferred n is ranged from 5 to 7.

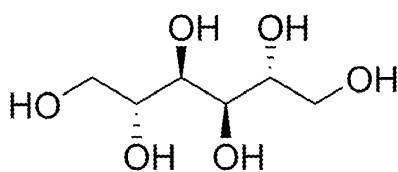
[0021] In these general molecular structures; R₁, R₂, R₃, and R₄ can be the same or different atoms or functional groups. They can be independently selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted

organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic ester, organic amine groups, and combinations thereof; wherein, at least two or more, preferably four of them are hydrogen atoms.

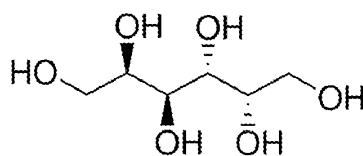
[0022] When R₁, R₂, R₃, and R₄ are the same and they are all hydrogen atoms, the non-ionic organic alcohol compounds have multi hydroxyl functional groups. The molecular structures of some examples are listed below:



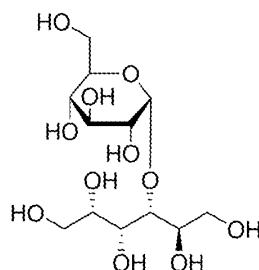
D-sorbitol;

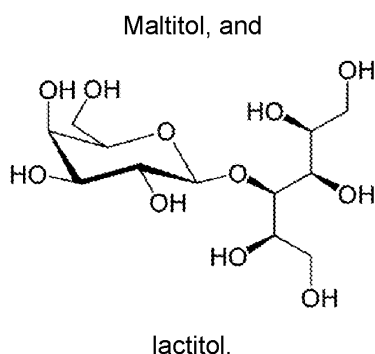


Mannitol;

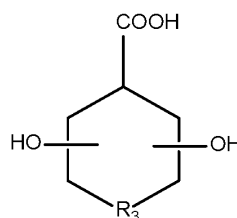
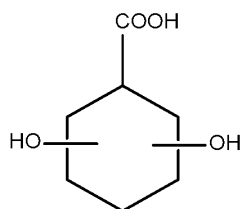
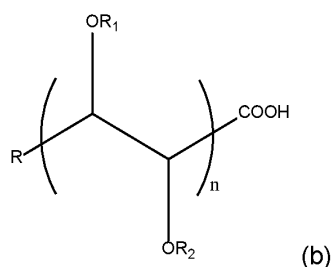


Dulcitol;





[0023] The chemical additives having one carboxylic acid group and at least two hydroxyl groups on the same molecules have a general molecular structure including but are not limited to the group comprising (b), (c) and (d) as shown below:



[0024] In general molecular structure (b), n is selected from 1 to 5,000, 1 to 200, or 1 to 20, the preferred n is from 2 to 12, the more preferred n is from 3 to 6.

[0025] R_1 and R_2 can be the same or different atoms or functional groups. They can be independently selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic ester, organic amine groups, and combinations thereof; wherein at least one of R_1 and R_2 is hydrogen. hydrogen.

[0026] R can be selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, organic amine groups, and combinations thereof.

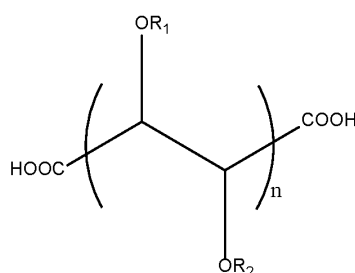
[0027] When both R_1 and R_2 are hydrogen atoms, the chemical additive bears one organic carboxylic groups and at least two hydroxyl functional groups.

[0028] Preferably, all R, R_1 and R_2 are hydrogen.

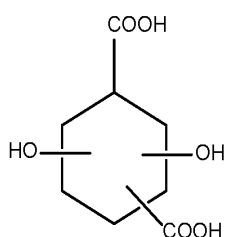
[0029] In general molecular structure (c), six member ring can contain (1) all carbon to carbon single bonds, and with one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds or as an aromatic ring with conjugated bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring.

[0030] In general molecular structure (d), six member ring can contain (1) four carbon to carbon single bonds and with R_3 as an oxygen atom to form two carbon to oxygen single bonds in six member ring, and with one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring.

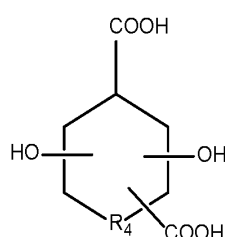
[0031] The chemical additives having two carboxylic acid group and at least two hydroxyl groups on the same molecules have a general molecular structure including but are not limited to the group comprising (e), (f), (g), (h), (i) and (j) as shown below:



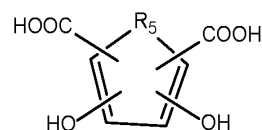
(e),



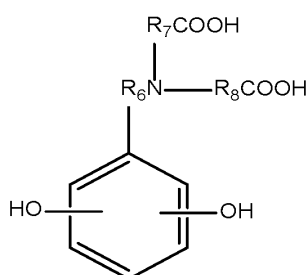
(f),



(g),

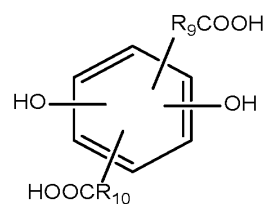


(h),



(i),

and



(j),

[0032] In general molecular structure (e), n is selected from 1 to 5,000, 1 to 200, or 1 to 20, the preferred n is from 2 to 12, the more preferred n is from 3 to 6.

[0033] R_1 and R_2 can be the same or different atoms or functional groups. They can be independently selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic ester, organic amine groups, and combinations thereof; wherein at least one of R_1 and R_2 is hydrogen.

[0034] When both R_1 and R_2 are hydrogen atoms, the chemical additive bears two organic carboxylic groups and at least two hydroxyl functional groups.

[0035] Preferably, R_1 and R_2 are hydrogen.

[0036] In general molecular structure (f), six member ring can contain (1) all carbon to carbon single bonds on the ring, and with two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds or as an aromatic ring with conjugated bonds, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring.

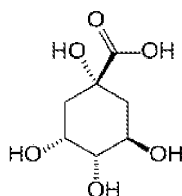
[0037] In general molecular structure (g), six member ring can contain (1) four carbon to carbon single bonds and with R_4 as an oxygen atom, a nitrogen atom or -NH- group to form two carbon to oxygen single bonds or carbon to nitrogen bonds in six member ring, and with two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds, or with the conjugated chemical bonds on six member ring and with two carboxylic acid groups and at least two hydroxyl groups directly bonded to 6 member ring.

[0038] In general molecular structure (h), R_5 can be an oxygen atom, and two carboxylic acid groups and two hydroxyl groups are directly bonded to five member ring.

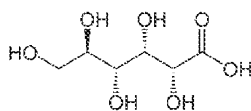
[0039] In general molecular structure (i), R_6 can be an alkyl group connecting to an aromatic ring and to an amino alkyl dicarboxylic acid group, R_7 and R_8 can be the same or different and are alkyl groups as $-(C_2H_4)_n-$ with n ranging from 1 to 6 and two hydroxyl groups are directly bonded to the six member ring.

[0040] In general molecular structure (j), R_9 and R_{10} can be the same or different and are alkyl groups, such as $-(C_2H_4)_n-$ with n ranging from 1 to 6, the at least two hydroxyl groups are directly bonded to the aromatic benzene ring.

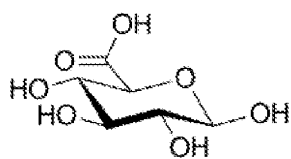
[0041] The molecular structures of the chemical additives bearing one organic carboxylic group and at least two hydroxyl functional groups include but are not limited to:



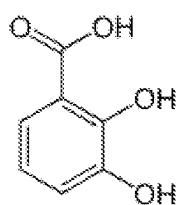
d-(-)-quinic acid;



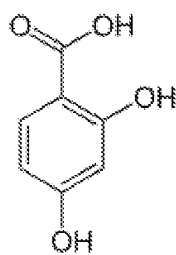
Gluconic acid;



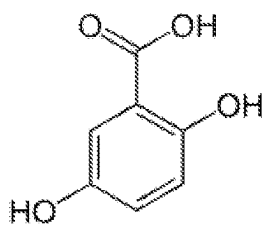
Glucuronic acid;



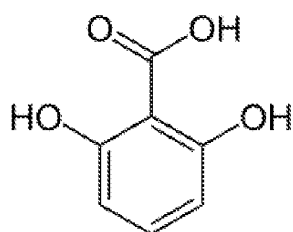
2,3-Dihydroxybenzoic acid;



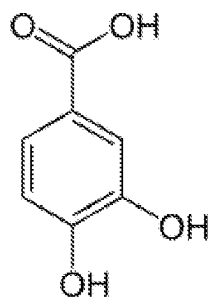
2,4-Dihydroxybenzoic acid;



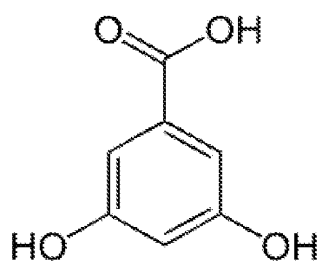
2,5-Dihydroxybenzoic acid;



2,6-Dihydroxybenzoic acid;

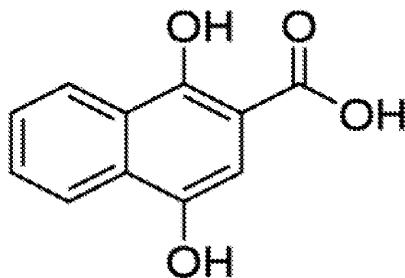


3,4-Dihydroxybenzoic acid:



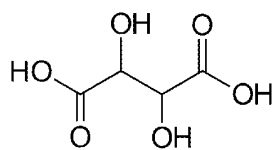
3,5-Dihydroxybenzoic acid;

and

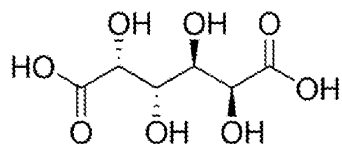


1,4-Dihydroxyl-2-naphthoic acid.

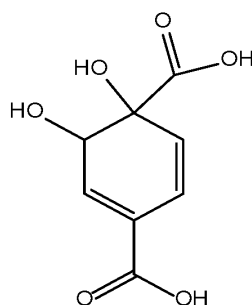
[0042] The molecular structures of the chemical additives bearing two organic carboxylic groups and at least two hydroxyl functional groups include but are not limited to:



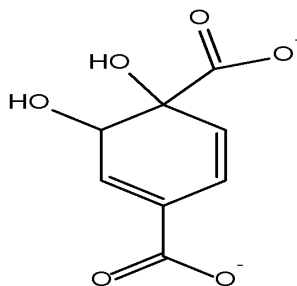
tartaric acid;



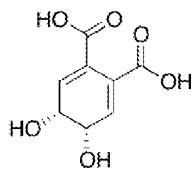
mucic acid;



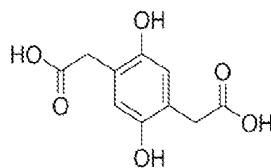
3,4-Dihydroxy-1,5-cyclohexadiene-1,4-dicarboxylic acid;



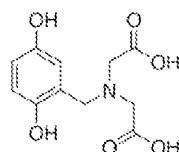
(1R,6S)-dihydroxycyclohexa-2,4-diene-1,4-dicarboxylate;



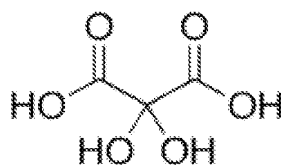
phthalic Acid 4,5-cis-Dihydrodiol;



2,5-Dihydroxy-1,4-benzenediacetic acid;

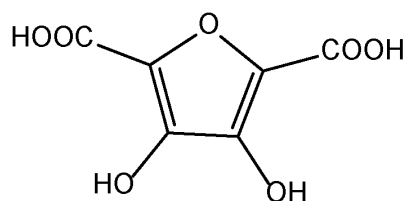


(carboxymethyl-(2,5-Dihydroxy-benzyl)-amino)-acetic acid;



Dihydroxymalonic acid;

and



3,4-Dihydroxy-2,5-furandicarboxylic acid.

[0043] In another aspect, there is provided a method of chemical mechanical polishing (CMP) a substrate having at least one surface comprising silicon dioxide using the chemical mechanical polishing (CMP) composition described above in Shallow Trench Isolation (STI) process.

[0044] In another aspect, there is provided a system of chemical mechanical polishing (CMP) a substrate having at least one surface comprising silicon dioxide using the chemical mechanical polishing (CMP) composition described above in Shallow Trench Isolation (STI) process.

[0045] The polished oxide films can be Chemical Vapor Deposition (CVD), Plasma Enhance CVD (PECVD), High Density Deposition CVD(HDP), or spin on oxide films.

[0046] The substrate disclosed above can further comprises a silicon nitride surface. The removal selectivity of SiO₂: SiN is greater than 70, 80, or 90.

DETAILED DESCRIPTION OF THE INVENTION

[0047] In the global planarization of patterned STI structures, suppressing SiN removal rates and increasing SiO₂ SiN selectivity and providing more reduced and lower erosions on low-density and narrow line features on the polished STI patterned wafers are key factors to be considered for advanced node STI CMP process. The reduced erosion on low-density and narrow line features will prevent electrical current leaking between adjacent transistors. Higher erosions on low-density and narrow line features will affect transistor performance and device fabrication yields. Therefore, it is important to reduce low-density and narrow line erosions by further reducing SiN removal rates and increasing SiO₂ SiN selectivity in STI CMP polishing compositions.

[0048] This invention relates to the Chemical mechanical polishing (CMP) compositions for Shallow Trench Isolation (STI) CMP applications.

[0049] More specifically, the disclosed chemical mechanical polishing (CMP) composition for Shallow Trench Isolation (STI) CMP applications have a unique combination of using ceria-coated inorganic oxide abrasive particles; non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecule; and a chemical additive to achieve the STI CMP performances with further reduced SiN removal rates, further increased SiO₂:SiN selectivity, and more importantly the effectively reduced erosions on the low-density and narrow sized features on the polished STI patterned wafers.

[0050] The use of the disclosed non-ionic organic alcohol compounds and the disclosed chemical additives having at least one preferably at least two carboxylic functional groups (or di-carboxylic functional group), and at least two hydroxyl groups on the same molecules provides the benefits of synergic effects in achieving further reduced SiN film removal rates, further increased silicon SiO₂ : SiN removal selectivity ratio (that is RR of SiO₂ : RR of SiN), and importantly, further reduced erosions on low-density and narrow line features on polishing patterned wafers.

[0051] In one aspect, there is provided a STI CMP polishing composition comprises, consist essentially of, or consists of:

ceria-coated inorganic oxide particles;

a non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules;

a chemical additive having at least one or at least two carboxylic functional groups (or bi-carboxylic functional group), and at least two hydroxyl groups on the same molecules;

a water-soluble solvent;

and optionally

biocide; and

pH adjuster;

wherein the composition has a pH of 2 to 12, preferably 3 to 11, more preferably 4 to 10, and most preferably 5 to 9.

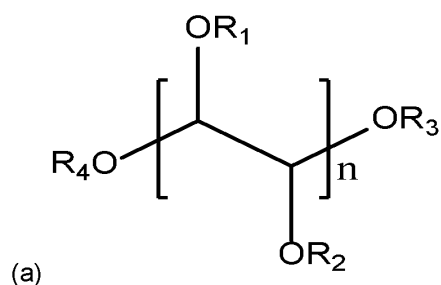
[0052] The ceria-coated inorganic oxide particles include, but are not limited to, ceria-coated colloidal silica, ceria-coated high purity colloidal silica, ceria-coated alumina, ceria-coated titania, ceria-coated zirconia, or any other ceria-coated inorganic oxide particles.

[0053] The particle sizes (measured by Dynamic Light Scattering DLS technology) of these ceria-coated inorganic metal oxide particles in the disclosed invention herein are ranged from 10nm to 1,000nm, the preferred mean particle sized are ranged from 20nm to 500nm, the more preferred mean particle sizes are ranged from 50nm to 250nm.

[0054] The concentrations of these ceria-coated inorganic oxide particles range from 0.01 wt.% to 20 wt.%, the preferred concentrations range from 0.05 wt.% to 10 wt.%, the more preferred concentrations range from 0.1 wt.% to 5 wt.%.

[0055] The preferred ceria-coated inorganic oxide particles are ceria-coated colloidal silica particles.

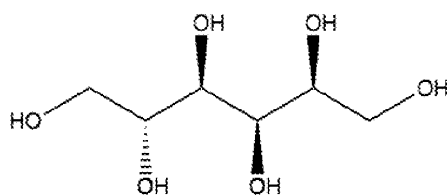
[0056] The non-ionic organic alcohol compounds with multi hydroxyl groups on the same molecules have a general molecular structure (a) as shown below:



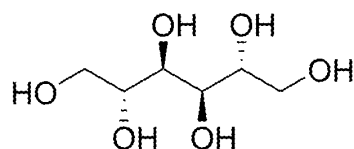
[0057] In the general molecular structures for the non-ionic organic alcohol compound, n is selected from 2 to 5,000, the preferred n is from 3 to 12, the more preferred n is ranged from 5 to 7.

[0058] In these general molecular structures; R_1 , R_2 , R_3 , and R_4 can be the same or different atoms or functional groups. They can be independently selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic ester, organic amine groups, and combinations thereof; wherein, at least two or more, preferably four of them are all hydrogen atoms.

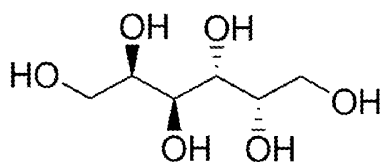
[0059] When R_1 , R_2 , R_3 and R_4 are the same and they are all hydrogen atoms, the non-ionic organic alcohol compounds have multi hydroxyl functional groups. The molecular structures of some examples are listed below:



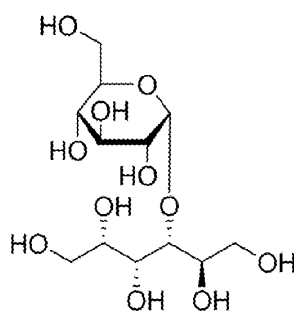
D-sorbitol;



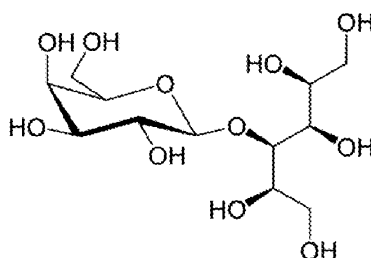
Mannitol;



Dulcitol;



Maltitol, and

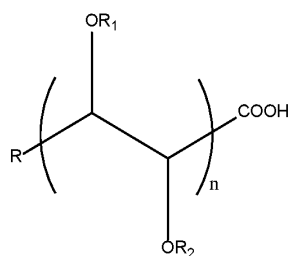


Lactitol.

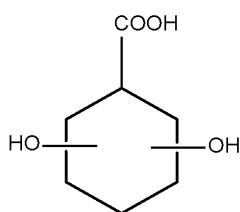
[0060] The STI CMP composition contains 0.0001 wt.% to 2.0% wt.%, 0.0002 wt.% to 1.0 wt.%, or 0.0005 wt.% to 0.5 wt.% of non-ionic organic alcohol compound as SiN film removal rate suppressing agents and low-density feature erosion reduction agents.

[0061] The chemical additives have at least one or at least two carboxylic functional groups (or bi-carboxylic functional group), and at least two hydroxyl groups on the same molecule.

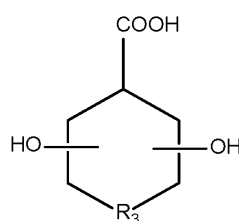
[0062] The chemical additives having one carboxylic acid group and at least two hydroxyl groups on the same molecules have a general molecular structure including but are not limited to the group comprising (b), (c) and (d) as shown below:



(b)



(c);



(d);

and

[0063] In general molecular structure (b), n is selected from 1 to 5,000, 1 to 200, or 1 to 20, the preferred n is from 2 to 12, the more preferred n is from 3 to 6.

[0064] R_1 and R_2 can be the same or different and each is independently selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic ester, organic amine groups, and combinations thereof; wherein at least one of R_1 and R_2 is hydrogen.

[0065] R can be selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, organic amine groups, and combinations thereof.

[0066] When both R_1 and R_2 are hydrogen atoms, the chemical additive bears one organic carboxylic groups and at least two hydroxyl functional groups.

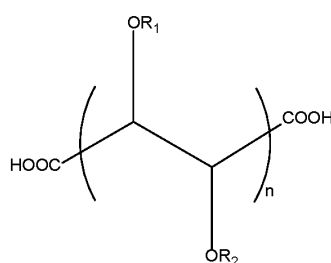
[0067] Preferably, all R , R_1 and R_2 are hydrogen.

[0068] In general molecular structure (c), six member ring can contain (1) all carbon to carbon single bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two

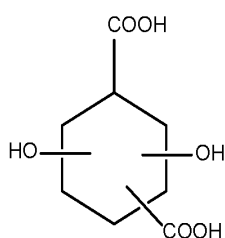
carbon to carbon double bonds or as an aromatic ring with conjugated bonds, and one carboxylic acid and at least two hydroxyl groups directly are bonded to six member ring.

[0069] In general molecular structure (d), six member ring can contain (1) four carbon to carbon single bonds and with R3 as an oxygen atom to form two carbon to oxygen single bonds in six member ring, and with one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring.

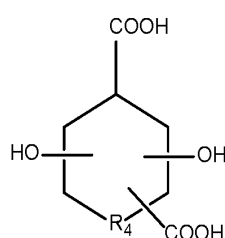
[0070] The chemical additives having two carboxylic acid group and at least two hydroxyl groups on the same molecules have a general molecular structure including but are not limited to the group comprising (e), (f), (g), (h), (i) and (j) as shown below:



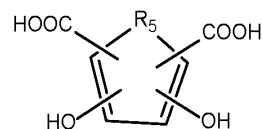
(e),



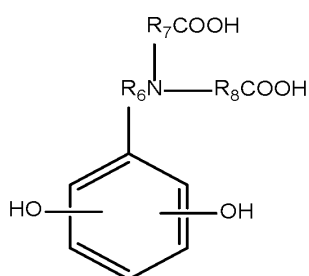
(f),



(g),

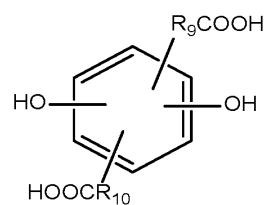


(h),



(i),

and



(j),

[0071] In general molecular structure (e), n is selected from 1 to 5,000, 1 to 200, or 1 to 20, the preferred n is from 2 to 12, the more preferred n is from 3 to 6.

[0072] R_1 and R_2 can be the same or different atoms or functional groups. They can be independently selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, substituted organic carboxylic acid, substituted organic carboxylic acid salt, organic carboxylic ester, organic amine groups, and combinations thereof; wherein at least one of R_1 and R_2 is hydrogen.

[0073] When both R_1 and R_2 are hydrogen atoms, the chemical additive bears two organic carboxylic groups and at least two hydroxyl functional groups.

[0074] Preferably, R_1 and R_2 are hydrogen.

[0075] In general molecular structure (f), six member ring can contain (1) all carbon to carbon single bonds on the ring, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds or as an aromatic ring with conjugated bonds, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring.

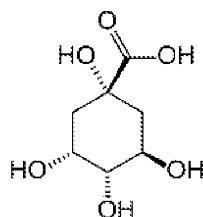
[0076] In general molecular structure (g), six member ring can contain (1) four carbon to carbon single bonds, R_4 can be an oxygen atom, a nitrogen atom or -NH- group to form two carbon to oxygen single bonds or carbon to nitrogen bonds in six member ring, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds or two carbon to carbon double bonds or with the conjugated chemical bonds on six member ring, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to 6 member ring.

[0077] In general molecular structure (h), R_5 can be an oxygen atom, and two carboxylic acid groups and two hydroxyl groups are directly bonded to five member ring.

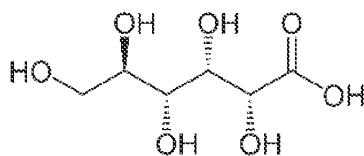
[0078] In general molecular structure (i), R_6 can be an alkyl group connecting to an aromatic ring and to an amino alkyl dicarboxylic acid group, R_7 and R_8 can be the same or different and each is an alkyl groups as $-(C_2H_4-)_n-$ with n ranging from 1 to 6, and two hydroxyl groups are directly bonded to the six member ring.

[0079] In general molecular structure (j), R_9 and R_{10} can be the same or different and each is an alkyl group, such as $-(C_2H_4-)_n-$ with n ranging from 1 to 6, the at least two hydroxyl groups are directly bonded to the aromatic benzene ring.

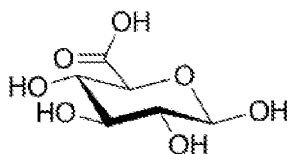
[0080] The molecular structures of some examples of the chemical additives bearing one organic carboxylic group and at least two hydroxyl functional groups are listed below:



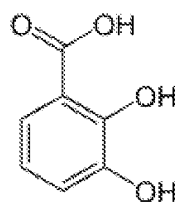
D- (-)-quinic acid;



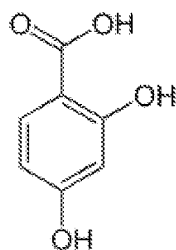
Gluconic acid;



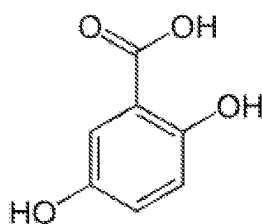
Glucuronic acid;



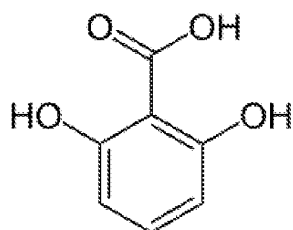
2,3-Dihydroxybenzoic acid;



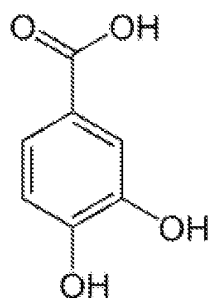
2,4-Dihydroxybenzoic acid;



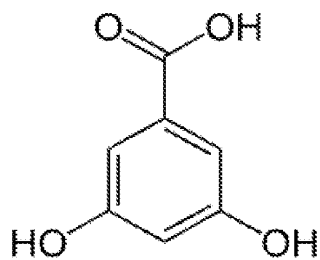
2,5-Dihydroxybenzoic acid;



2,6-Dihydroxybenzoic acid;

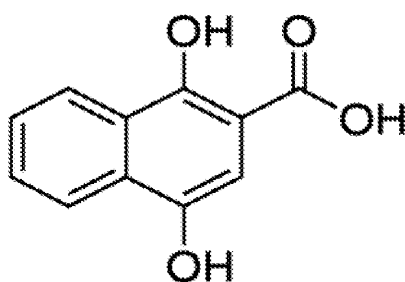


3,4-Dihydroxybenzoic acid:



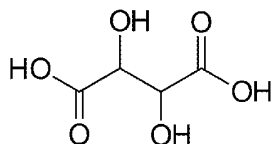
3,5-Dihydroxybenzoic acid;

and

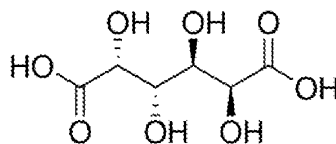


1,4-Dihydroxyl-2-naphthoic acid.

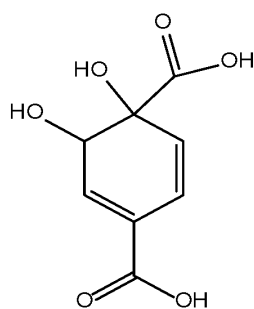
[0081] The molecular structures of some examples of the chemical additives bearing two organic carboxylic groups and at least two hydroxyl functional groups are listed below:



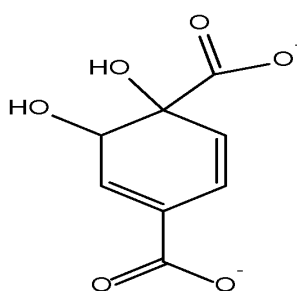
tartaric acid;



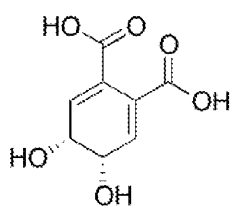
mucic acid;



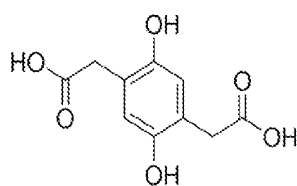
3,4-Dihydroxy-1,5-cyclohexadiene-1,4-dicarboxylic acid;



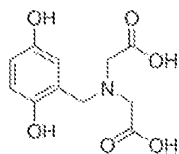
(1R,6S)-dihydroxycyclohexa-2,4-diene-1,4-dicarboxylate;



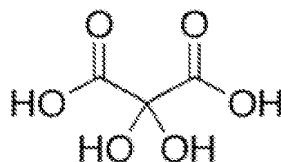
phthalic Acid 4,5-cis-Dihydrodiol;



2,5-Dihydroxy-1,4-benzenediacetic acid;

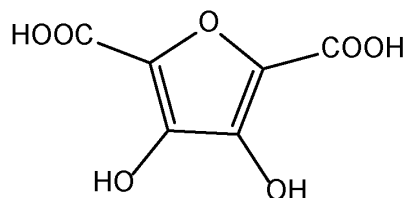


(carboxymethyl-(2,5-Dihydroxy-benzyl)-amino)-acetic acid;



Dihydroxymalonic acid;

and



3,4-Dihydroxy-2,5-furandicarboxylic acid.

[0082] The STI CMP composition contains 0.0001 wt.% to 2.0% wt.%, 0.0002 wt.% to 1.0 wt.%, 0.0005 wt.% to 0.5 wt.%, or 0.0025 wt.% to 0.015 wt.% of the chemical additive-as SiN film removal rate suppressing agents and low-density feature erosion reduction agents.

[0083] The water-soluble solvent includes but is not limited to deionized (DI) water, distilled water, and alcoholic organic solvents.

[0084] The preferred water-soluble solvent is DI water.

[0085] The STI CMP composition may contain biocide 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.%.

[0086] The biocide includes, but is not limited to, Kathon™, Kathon™ CG/ICP II, from Dupont/Dow Chemical Co. Bioban from Dupont/Dow Chemical Co. They have active

ingredients of 5-chloro-2-methyl-4-isothiazolin-3-one, 2-methyl-4-isothiazolin-3-one, 2-n-Octyl-4-isothiazolin-3-one.

[0087] The STI CMP composition may contain a pH adjusting agent.

[0088] An acidic or neutral or basic pH adjusting agent can be used to adjust the STI polishing compositions to the optimized pH value.

[0089] The pH adjusting agents include, but are not limited to nitric acid, hydrochloric acid, sulfuric acid, phosphoric acid, other inorganic or organic acids, and mixtures thereof to adjust pH towards the more acidic direction.

[0090] pH adjusting agents also include the basic pH adjusting agents, such as sodium hydride, potassium hydroxide, ammonium hydroxide, tetraalkyl ammonium hydroxide, organic quaternary ammonium hydroxide compounds, organic amines, and other chemical reagents that can be used to adjust pH towards the more alkaline direction.

[0091] The STI CMP composition contains 0 wt.% to 1 wt.%; preferably 0.01 wt.% to 0.5 wt.%; more preferably 0.1 wt.% to 0.25 wt.% pH adjusting agent.

[0092] In another aspect, there is provided a method of chemical mechanical polishing (CMP) a substrate having at least one surface comprising silicon dioxide using the chemical mechanical polishing (CMP) composition described above in Shallow Trench Isolation (STI) process.

[0093] In another aspect, there is provided a system of chemical mechanical polishing (CMP) a substrate having at least one surface comprising silicon dioxide using the chemical mechanical polishing (CMP) composition described above in Shallow Trench Isolation (STI) process.

[0094] The polished oxide films can be Chemical vapor deposition (CVD), Plasma Enhance CVD (PECVD), High Density Deposition CVD(HDP), or spin on oxide films.

[0095] The substrate disclosed above can further comprises a silicon nitride surface. The removal selectivity of SiO₂: SiN is greater than 70, 80, or 90.

[0096] In another aspect, there is provided a method of chemical mechanical polishing (CMP) a substrate having at least one surface comprising silicon dioxide using the chemical mechanical polishing (CMP) composition described above in Shallow

Trench Isolation (STI) process. The polished oxide films can be CVD oxide, PECVD oxide, High density oxide, or Spin on oxide films.

[0097] The following non-limiting examples are presented to further illustrate the present invention.

CMP Methodology

[0098] In the examples presented below, CMP experiments were run using the procedures and experimental conditions given below.

GLOSSARY

COMPONENTS

[0099] Ceria-coated Silica: used as abrasive having a mean particle size of approximately 120 nanometers (nm).

[00100] Ceria-coated Silica particles (with varied sizes) were supplied by JGC Inc. in Japan and were made by methods described in JP2013119131 and JP2013133255; WO 2016/159167; JP patent applications JP2015-169967; and JP2015-183942.

[00101] Chemical additives, such as maltitol, mucic acid, tartaric acid and all other chemical raw materials were supplied by MilliporeSigma, St. Louis, MO

[00102] TEOS: tetraethyl orthosilicate

[00103] Polishing Pad: Polishing pad, IC1010 and other pads were used during CMP, supplied by DOW, Inc.

PARAMETERS

General

[00104] Å or A: angstrom(s) – a unit of length

[00105] BP: back pressure, in psi units

[00106] CMP: chemical mechanical planarization = chemical mechanical polishing

[00107] CS: carrier speed

[00108] DF: Down force: pressure applied during CMP, unit: psi

[00109] min: minute(s)

[00110] ml: milliliter(s)

[00111] mV: millivolt(s)

[00112] mM: millimolar

[00113] psi: pounds per square inch

[00114] PS: platen rotational speed of polishing tool, in rpm (revolution(s) per minute)

[00115] SF: composition flow, ml/min

[00116] Wt. %: weight percentage (of a listed component)

[00117] TEOS: SiN Selectivity: (removal rate of TEOS)/ (removal rate of SiN)

[00118] HDP: high density plasma deposited TEOS

[00119] TEOS or HDP Removal Rates: Measured TEOS or HDP removal rate at a given down pressure. The down pressure of the CMP tool was 2.0, 3.0 or 4.0 psi in the examples listed above.

[00120] SiN Removal Rates: Measured SiN removal rate at a given down pressure. The down pressure of the CMP tool was 3.0 psi in the examples listed.

Metrology

[00121] Films were measured with a ResMap CDE, model 168, manufactured by Creative Design Engineering, Inc, 20565 Alves Dr., Cupertino, CA, 95014. The ResMap tool is a four-point probe sheet resistance tool. Forty-nine-point diameter scan at 5mm edge exclusion for film was taken.

CMP Tool

[00122] The CMP tool that was used is a 200mm Mirra, or 300mm Reflexion manufactured by Applied Materials, 3050 Bowers Avenue, Santa Clara, California, 95054. An IC1000 pad supplied by DOW, Inc, 451 Bellevue Rd., Newark, DE 19713 was used on platen 1 for blanket and pattern wafer studies.

[00123] The IC1010 pad or other pad was broken in by conditioning the pad for 18 mins. At 7 lbs. down force on the conditioner. To qualify the tool settings and the pad break-in four TEOS monitors were polished with Versum® STI2305 composition, supplied by Versum Materials Inc. at baseline conditions.

Wafers

[00124] Polishing experiments were conducted using PECVD or LECVD or HD TEOS wafers, and SiN wafers, the patterned wafer are MIT864 oxide patterned wafer. These blanket and patterned wafers were purchased from Silicon Valley Microelectronics, 2985 Kifer Rd., Santa Clara, CA 95051.

Polishing Experiments

[00125] In blanket wafer studies, oxide blanket wafers, and SiN blanket wafers were polished at baseline conditions. The tool baseline conditions were: table speed; 87 rpm, head speed: 93 rpm, membrane pressure; 3.0 psi, composition flow; 200 ml/min., Saesol E4 disk was used for 100% in-situ conditioning.

[00126] These polished patterned wafers (MIT864) wafers were measured on the Veeco VX300 profiler/AFM instrument.

[00127] TEOS: SiN Selectivity ratio: (removal rate of TEOS)/ (removal rate of SiN) obtained from the STI CMP polishing compositions were tunable. The lower or reduced P200 Oxide Trench loss rate indicated the improved topography data, such as the reduced erosions on the narrow-featured lines and lower density features.

[00128] Different sized oxide trench RR/Blanket oxide film RR ratio is a key parameter to judge on whether the oxide polishing composition can afford lower oxide dishing while used for oxide CMP polishing applications. In general, the smaller of such ratios are, the lower of oxide trench dishing are.

Example 1

[00129] In Example 1, STI polishing references 1 and 3(Ref. 1 and Ref. 3) compositions were prepared using 0.2 wt.% ceria-coated silica, 0.00039 wt.% Bioban 425 as biocide, 0.8 millimolar (mM) maltitol (or 0.28 wt.%) or 0.8 mM D-sorbitol (or 0.15

wt.%) as the non-ionic organic alcohol compound (alcohol) and deionized water at pH 7, respectively. Ref. 2 was prepared by adding 0.024 mM Adipic Acid (not a claimed chemical additive) to Ref. 1. 0.024 mM different chemical additives were added to Ref. 1 to obtain working examples Comp 1 to 6. The concentration of the non-ionic organic alcohol alcohols and the chemical additives was in mM for better comparison purpose.

[00130] The removal rates (RR at Å/min) of TEOS (silicon oxide blanket wafers) and SiN (blanket wafers), and P200 Trench Loss rates on the polished MIT864 patterned wafers were measured. The ratio of P200 Trench Loss rate/blanket RR was calculated. The test results were listed in Table 1. The ratio of P200 Trench Loss rate/blanket RR was calculated and listed in Table 1 as well.

Table 1. Film RR (Å /min.), TEOS: SiN Selectivity, P200 Trench Loss Rate (Å /min.) and ratio of P200 Oxide Trench Loss Rate/Blanket oxide RR

Comp.	Alcohol (0.8mM)	Additive	Conc. (mM)	SiO ₂ RR (Å/min)	SiN RR (Å /min)	Selectivity	P200 Trench Loss Rate (Å /min)	P200 Trench Loss Rate / Blanket RR
Ref. 1	Maltitol	None	0	3082	40	77	174	0.06
1	Maltitol	Adipic Acid	0.024	2620	30	87	276	0.11
2	Maltitol	Gluconic acid	0.024	2012	28	72	150	0.07
3	Maltitol	Mucic acid	0.024	2368	27	89	138	0.06
4	Maltitol	L-(+)-Tartaric acid	0.024	2374	26	91	162	0.07
5	Maltitol	D-Glucuronic acid	0.024	3009	34	90	174	0.06
6	Maltitol	D-(-)-Quinic acid	0.024	3020	34	89	204	0.07
Ref. 2	D-Sorbitol	None	0	2454	71	35	228	0.09
Ref. 3	D-Sorbitol	Mucic Acid	0.024	2246	39	58	185	0.08

[00131] As the results shown in Table 1, most data for compositions using 0.8mM non-ionic organic alcohol compound (maltitol or D-sorbitol) and 0.024mM chemical additive have shown effectively reduced RR for SiN and improved SiO₂ : SiN film selectivity; improved P200 Trench Loss Rate (Å/min.) and P200 Trench Loss Ratio. Reduced RR for SiN is desired for STI polishing and when combined with low Trench Loss Rate can provide low erosion on polishing oxide patterned wafers.

[00132] Please note that adipic acid is not a disclosed chemical additive. It was just used as reference. Adipic acid structure is similar to mucic acid but has no hydroxyl group. The composition with adipic acid reduced nitride removal rate and improved the

selectivity of SiO₂ vs SiN, however, the composition had the worse P200 Trench Loss Rate (Å/min.) and the worst ratio of P200 Trench Loss Rate (Å /min.) to blanket removal rate.

[00133] Thus, the chemical additive without having at least one or at least two carboxylic functional groups, and at least two hydroxyl groups on the same molecule cannot improve P200 Trench Loss Rate (Å/min.) and the ratio of P200 Trench Loss Rate (Å /min.) to blanket removal rate.

Example 2

[00134] In Example 2, all polishing compositions used 0.2 wt.% ceria-coated silica, 0.00039 wt.% Bioban 425 as biocide, and deionized water.

[00135] The CMP polishing compositions in Table 2 were prepared with (1) fixed concentrations of non-ionic organic alcohol compound (alcohol) and chemical additives but at various pH; fixed non-ionic organic alcohol compound (alcohol) concentration and various concentrations of chemical additives at fixed pH; or fixed chemical additives concentration and various concentrations of non-ionic organic alcohol compound (alcohol) at fixed pH.

[00136] The removal rates (RR at Å/min) of oxide (blanket wafers) and SiN (blanket wafers), and P200 Trench Loss rates on the polished MIT864 patterned wafers were measured. The test results were listed in Table 2.

Table 2 Film RR (Å/min.), TEOS: SiN Selectivity, P200 Trench Loss Rate (Å /min.) and ratio of P200 Oxide Trench Loss Rate/Blanket oxide RR

Comp.	Alcohol	Alcohol Conc. (mM)	Chemical Additive	Conc. (mM)	pH	SiO ₂ RR (Å/min)	SiN RR (Å /min)	Selectivity	P200 Trench Loss Rate (Å /min)	P200 Trench Loss Rate / Blanket RR
Ref. 1	Maltitol	0.8	None	0	7	3082	40	77	174	0.06
Ref. 4	Maltitol	0.8	none	0	5.4	2866	44	65	168	006
7	Maltitol	0.8	Mucic acid	0.024	6	2454	31	79	119	0.05
2	Maltitol	0.8	Mucic acid	0.024	7	2368	27	89	138	0.06
8	Maltitol	0.8	Mucic acid	0.024	8	2613	27	99	120	0.05
2	Maltitol	0.8	Mucic acid	0.024	7	2368	27	89	138	0.06
9	Maltitol	0.8	Mucic Acid	0.067	7	2047	31	67	124	0.06

3	Maltitol	0.8	L-(+)-Tartaric acid	0.024	7	2374	26	91	162	0.07
10	Maltitol	0.8	L-(+)-Tartaric acid	0.067	7	2298	29	79	168	0.07
3	Maltitol	0.8	L-(+)-Tartaric acid	0.024	7	2374	26	91	162	0.07
11	Maltitol	0.8	L-(+)-Tartaric Acid	0.024	8	1948	34	57	180	0.09
11	Maltitol	0.8	L-(+)-Tartaric Acid	0.024	8	1948	34	57	180	0.09
12	D-Sorbitol	0.8	L-(+)-Tartaric Acid	0.024	8	2015	46	44	213	0.11
13	Lactitol	0.4	L-(+)-Tartaric Acid	0.024	8	2184	46	48	326	0.15
1	Maltitol	0.8	D-Glucuronic acid	0.024	7	3009	34	90	174	0.06
14	Maltitol	0.8	D-Glucuronic acid	0.052	7	2934	30	98	156	0.05
Ref. 5	Maltitol	0.6	None	0	7	2713	47	58	372	0.14
15	Maltitol	0.6	L-(+)-Tartaric acid	0.093	7	1829	57	32	200	0.11
Ref. 6	Maltitol	0.4	None	0	7	3720	83	45	385	0.10
16	Maltitol	0.4	D-(-)-Quinic acid	0.067	7	2341	39	60	286	0.12
17	Maltitol	0.4	L-(+)-Tartaric acid	0.067	7	1844	64	29	236	0.13
18	Maltitol	0.4	D-Glucuronic acid	0.067	7	2415	37	66	187	0.08

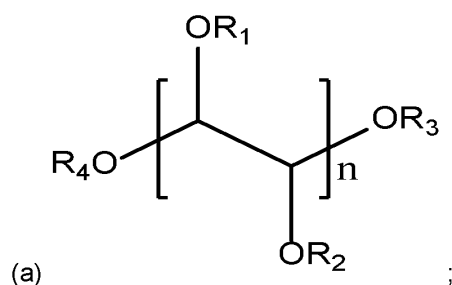
[00137] Data in Table 2 has shown effectively reduced RR for SiN and improved SiO₂: SiN film selectivity; while with improved or maintained P200 Trench Loss Rate (Å/min.) and ratio of P200 Oxide Trench Loss Rate (Å /min.) to blanket oxide removal rate.

[00138] As demonstrated in the working examples, using a chemical additive having at least one or at least two carboxylic functional groups (or bi-carboxylic functional group) and at least two hydroxyl groups on the same molecule with a non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecule, can lower nitride rate and improve selectivity while provide low erosions on various sized features of the polished STI patterned wafers and low oxide trench dishing for polishing oxide patterned wafers.

[00139] The embodiments of this invention listed above, including the working example, are exemplary of numerous embodiments that may be made of this invention. It is contemplated that numerous other configurations of the process may be used, and the materials used in the process may be elected from numerous materials other than those specifically disclosed.

Claims

1. A Chemical Mechanical Planarization polishing composition comprises:
0.01 wt.% to 20 wt.%, 0.05 wt.% to 10 wt.%, or 0.1 wt.% to 5 wt.% of ceria-coated inorganic oxide particles.
0.0001 wt.% to 2.0% wt.%, 0.0002 wt.% to 1.0 wt.%, or 0.0005 wt.% to 0.5 wt.% of non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules;
0.0001 wt.% to 2.0% wt.%, 0.0002 wt.% to 1.0 wt.%, 0.0005 wt.% to 0.5 wt.%, or 0.0025 wt.% to 0.015 wt.% of a chemical additive having at least one or at least two carboxylic functional groups, and at least two hydroxyl groups on the same molecules;
a water-soluble solvent;
and optionally
0.00 wt.% to 0.05 wt.%, 0.0005 wt.% to 0.025 wt.%, or 0.001 wt.% to 0.01 wt.% of biocide; and
0 wt.% to 1 wt.%, 0.01 wt.% to 0.5 wt.%, or 0.1 wt.% to 0.25 wt.% of a pH adjuster;
wherein the composition has a pH of 2 to 12, 3 to 11, 4 to 10, or 5 to 9.
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 silica, ceria-coated colloidal silica, ceria-coated alumina, ceria-coated titania, ceria-coated zirconia, and combinations thereof.
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 composition of Claim 1, wherein the non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules has a general molecular structure (a) as shown below:

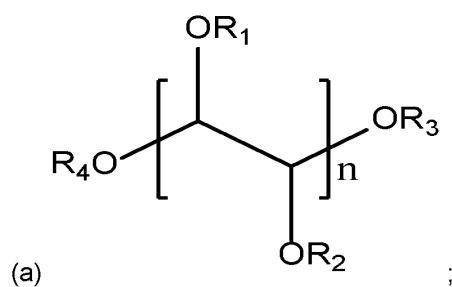


wherein

n is selected from 2 to 5,000, 3 to 12, or 5 to 7;

R₁, R₂, R₃, and R₄ can be the same or different atoms or functional groups and can be independently selected from the group consisting of hydrogen, alkyl, 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 ester, organic amine groups, and combinations thereof.

5. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules has a general molecular structure (a) as shown below:

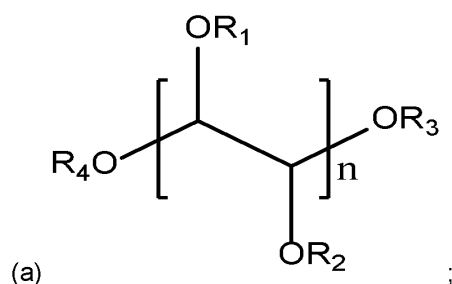


wherein

n is selected from 2 to 5,000, 3 to 12, or 5 to 7; and

at least two of R₁, R₂, R₃, and R₄ are hydrogen atoms.

6. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules has a general molecular structure (a) as shown below:

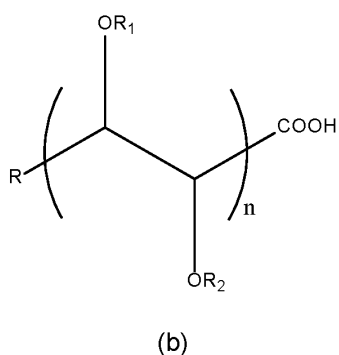


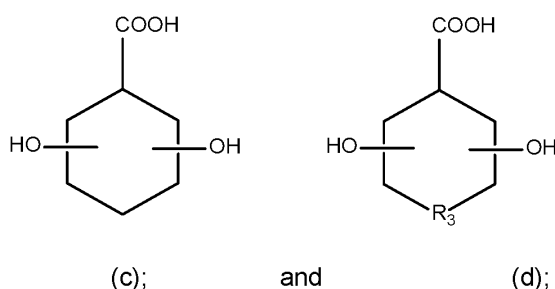
wherein

n is selected from 2 to 5,000, 3 to 12, or 5 to 7; and

all R₁, R₂, R₃, and R₄ are hydrogen atoms.

7. The chemical mechanical polishing composition of Claim 1, wherein the non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules is selected from the group consisting of D-sorbitol, mannitol, dulcitol, maltitol, lactitol and combinations thereof.
8. The chemical mechanical polishing composition of Claim 1, wherein the chemical additive has at least one carboxylic functional group and at least two hydroxyl groups on the same molecules; and has a general molecular structure selected from the group consisting of:





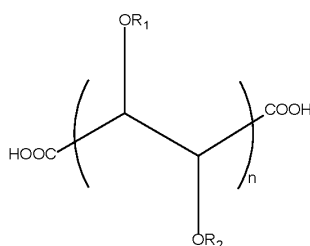
wherein:

in (b), n is selected from 1 to 5,000, 1 to 200, or 1 to 20, the preferred n is from 2 to 12, the more preferred n is from 3 to 6; R_1 and R_2 can be the same or different and each is independently selected from the group consisting of hydrogen, alkyl, 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 ester, organic amine groups, and combinations thereof; wherein at least one of R_1 and R_2 is hydrogen; R can be selected from the group consisting of hydrogen, alkyl, alkoxy, organic group with one or more hydroxyl groups, substituted organic sulfonic acid, substituted organic sulfonic acid salt, organic amine groups, and combinations thereof; preferably R_1 and R_2 are hydrogen or all R , R_1 and R_2 are hydrogen;

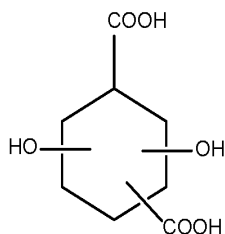
in (c), six member ring can contain (1) all carbon to carbon single bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds, two carbon to carbon double bonds, or as an aromatic ring with conjugated bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring;

in (d), six member ring can contain (1) four carbon to carbon single bonds and R_3 as an oxygen atom to form two carbon to oxygen single bonds, one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring; or (2) one or two carbon to carbon double bonds, and one carboxylic acid and at least two hydroxyl groups directly bonded to six member ring.

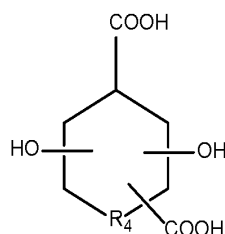
9. The chemical mechanical polishing composition of Claim 1, wherein the chemical additive has at least two carboxylic functional groups and at least two hydroxyl groups on the same molecules; and has a general molecular structure selected from the group consisting of:



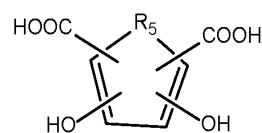
(e),



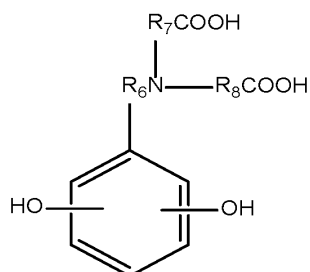
(f),



(g),

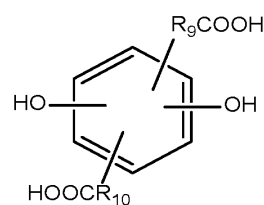


(h),



(i),

and



(j),

wherein

in (e), n is selected from 1 to 5,000, 1 to 200, or 1 to 20, the preferred n is from 2 to 12, the more preferred n is from 3 to 6; R_1 and R_2 can be the same or different atoms or functional groups and each is independently selected from the group consisting of hydrogen, alkyl, 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 ester, organic amine groups, and combinations thereof; wherein at least one of R_1 and R_2 is hydrogen; preferably, R_1 and R_2 are hydrogen;

in (f), six member ring can contain (1) all carbon to carbon single bonds on the ring, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds, two carbon to carbon double bonds, or as an aromatic ring with conjugated bonds, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring;

in (g), six member ring can contain (1) four carbon to carbon single bonds, R_4 can be an oxygen atom, a nitrogen atom, or -NH- group to form two carbon to oxygen single bonds or carbon to nitrogen bonds, and two carboxylic acid groups and at least two hydroxyl groups directly bonded to six member ring; or (2) one carbon to carbon double bonds, two carbon to carbon double bonds, or the conjugated chemical bonds on six member ring; and two carboxylic acid groups and at least two hydroxyl groups directly bonded to 6 member ring;

in (h), R_5 can be an oxygen atom, and two carboxylic acid groups and two hydroxyl groups are directly bonded to five member ring;

in (i), R_6 can be an alkyl group connecting to an aromatic ring and to an amino alkyl dicarboxylic acid group, R_7 and R_8 can be the same or different and each is an alkyl group as $-(C_2H_4)_n-$ with n ranging from 1 to 6, and two hydroxyl groups are directly bonded to the six member ring; and

in (j), R_9 and R_{10} can be the same or different and each is an alkyl group, such as $-(C_2H_4)_n-$ with n ranging from 1 to 6, the at least two hydroxyl groups are directly bonded to the aromatic benzene ring.

10. The chemical mechanical polishing composition of Claim 1, wherein the chemical additive has at least one carboxylic functional group and at least two hydroxyl groups on the same molecule; and is selected from the group consisting of D-(-)-Quinic acid, Gluconic acid, D-Glucuronic acid, 2,3-Dihydroxybenzoic acid, 2,3-Dihydroxybenzoic acid, 2,4-Dihydroxybenzoic acid, 2,5-Dihydroxybenzoic acid,

2,6-Dihydroxybenzoic acid, 3,4-Dihydroxybenzoic acid, 3,5-Dihydroxybenzoic acid, 1,4-Dihydroxyl-2-naphthoic acid, and combinations thereof.

11. The chemical mechanical polishing composition of Claim 1, wherein the chemical additive has at least one carboxylic functional group and at least two hydroxyl groups on the same molecule; and is selected from the group consisting of D-(-)-Quinic acid, Gluconic acid, D-Glucuronic acid, and combinations thereof.
12. The chemical mechanical polishing composition of Claim 1, wherein the chemical additives having at least two carboxylic functional groups, and at least two hydroxyl groups on the same molecule is selected from the group consisting of tartaric acid; mucic acid, 3,4-Dihydroxy-1,5-cyclohexadiene-1,4-dicarboxylic acid; (1R,6S)-dihydroxycyclohexa-2,4-diene-1,4 dicarboxylate; phthalic Acid 4,5-cis-Dihydrodiol; 2,5-Dihydroxy-1,4-benzenediacetic acid; (carboxymethyl-(2,5-Dihydroxy-benzyl)-amino)-acetic acid; Dihydroxymalonic acid; 3,4-Dihydroxy-2,5-furandicarboxylic acid; and combinations thereof.
13. The chemical mechanical polishing composition of Claim 1, wherein the chemical additives having at least two carboxylic functional groups, and at least two hydroxyl groups on the same molecule is selected from the group consisting of tartaric acid; mucic acid, and combinations thereof.
14. The chemical mechanical polishing composition of Claim 1, wherein the composition comprises ceria coated silica; tartaric acid, gluconic acid, mucic acid, D-glucuronic acid, D-(-)-quinic acid, or combinations thereof; and maltitol, D-sorbitol, lactitol or combinations thereof.
15. The chemical mechanical polishing composition of Claim 1, wherein the composition comprises 0.1 wt.% to 5 wt.% ceria coated silica; 0.0025 wt.% to 0.015 wt.% tartaric acid, gluconic acid, mucic acid, D-glucuronic acid, D-(-)-quinic acid, or combinations thereof; and 0.0005 wt.% to 0.5 wt.% maltitol, D-sorbitol, lactitol or combinations thereof.

16. The chemical mechanical polishing composition of Claim 1, wherein the composition comprising:
- 0.05 wt.% to 10 wt.% or 0.1 wt.% to 5 wt.% of ceria-coated inorganic oxide particles.
- 0.0002 wt.% to 1.0 wt.% or 0.0005 wt.% to 0.5 wt.% of non-ionic organic alcohol compound having multi hydroxyl groups bearing on the same molecules;
- 0.0005 wt.% to 0.5 wt.% or 0.0025 wt.% to 0.015 wt.% of a chemical additive having at least one or at least two carboxylic functional groups, and at least two hydroxyl groups on the same molecules;
- a water-soluble solvent;
- and optionally
- 0.0005 wt.% to 0.025 wt.% or 0.001 wt.% to 0.01 wt.% of biocide; and
- 0.01 wt.% to 0.5 wt.% or 0.1 wt.% to 0.25 wt.% of a pH adjuster;
- wherein the composition has a pH of 4 to 10 or 5 to 9.
17. The chemical mechanical polishing composition of Claim 1, wherein the composition has a pH of 2 to 12 or 3 to 11.
18. The chemical mechanical polishing composition of Claim 1, wherein the composition has a pH of 3 to 11 or 4 to 10.
19. The chemical mechanical polishing composition of Claim 1, wherein the composition has a pH of 4 to 10 or 5 to 9.
20. The chemical mechanical polishing composition of Claim 1, wherein the composition further comprises at least one selected from the group consisting of:
- biocide having active ingredients of 5-chloro-2-methyl-4-isothiazolin-3-one, 2-methyl-4-isothiazolin-3-one, or 2-n-Octyl-4-isothiazolin-3-one; and
- pH adjusting agent 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 silicon oxide film, comprising providing the semiconductor substrate; providing a polishing pad; providing the chemical mechanical polishing (CMP) composition in any of claims 1 to 20; contacting the surface of the semiconductor substrate with the polishing pad and the chemical mechanical polishing composition; and polishing the least one surface comprising silicon dioxide.
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 semiconductor substrate further comprises a surface containing silicon nitride, and removal selectivity of $\text{SiO}_2:\text{SiN}$ is greater than 70, 80, or 90.
24. A system of chemical mechanical polishing (CMP) a semiconductor substrate having at least one surface comprising silicon oxide film, comprising
- a. the semiconductor substrate;
 - b. the chemical mechanical polishing (CMP) composition in any one of Claim 1 to 20;
 - c. a polishing pad;
- wherein the at least one surface comprising silicon oxide film is in contact with the polishing pad and the chemical mechanical polishing composition.
25. The system of claim 24; 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.

26. The system of claim 24; wherein the semiconductor substrate further comprises a surface containing silicon nitride, and removal selectivity of $\text{SiO}_2:\text{SiN}$ is greater than 70, 80, or 90.