Claims

1. A polishing composition comprising:
abrasive particles ranging from 0.01 wt.% to 15 wt.%;
a compound to enhance removal rate of films comprising elemental silicon ranging from 0.001 wt.% to 0.5 wt.%; and
liquid carrier; and
pH of the polishing composition is between 2 and 12;
wherein
the abrasive particles are selected from the group consisting of fumed silica, colloidal silica, fumed alumina, colloidal alumina, cerium oxide, ceria-silica composite particles, titanium dioxide, zirconium oxide, polystyrene, polymethyl methacrylate, mica, hydrated aluminum silicate, and mixtures thereof; and
the compound to enhance removal rate of films comprising elemental silicon is selected from the group consisting of (i) heterocycle carbon compound comprising sulfur or nitrogen or both sulfur and nitrogen as heteroatoms and a carbonyl group attached to the ring structure; (ii) heterocycle carbon compound comprising sulfur or nitrogen or both sulfur and nitrogen as heteroatoms; (iii)an aldehyde or a ketone compound; and combinations thereof.

2. The polishing composition of Claim 1, wherein the compound to enhance removal rate of films comprising elemental silicon is selected from the group consisting of isothiazolinone and derivatives, thiazolinone and derivatives.

3. The polishing composition of Claim 2, wherein the isothiazolinone and derivative is selected from the group consisting of methylisothiazolinone (MIT), chloromethylisothiazolinone (CMIT), benzisothiazolinone (BIT), octylisothiazolinone (OIT), dichlorooctylisothiazolinone (DCOIT), butylbenzisothiazolinone (BBIT), and combinations thereof; and the thiazolinone and derivative is selected from the group consisting of 2-Benzothiazol-1,1,3-trione (Saccharin), N-methyl 2-Benzothiazolinone, thiazolinone, and combinations thereof.

4. The polishing composition of Claim 1, wherein the compound to enhance removal rate of films comprising elemental silicon is selected from the group consisting of

imidazolidine and derivatives, pyrozolidine and derivatives, imidazole and derivatives, pyrazole and derivatives, thiazole and derivatives, isothiazole and derivatives, thiazolidine and derivatives, isothiazolidine and derivatives, dithiolane and derivatives, triazole and derivatives, tetrazole and derivatives, thiadiazole and derivatives, and combinations thereof; or is selected from the group consisting of acetone, benzophenone, acetophenone, acetylacetone, butanol, 3-hydroxybutanal, p-nitrobenzaldehyde, cinnamaldehyde, vanillin, and combinations thereof.

5. The polishing composition of Claim 1, wherein the liquid carrier is water; and the pH of the polishing composition is between 4 and 10.

6. The polishing composition of claim 5, wherein, the abrasive particles comprise ceria-silica composite particles and colloidal silica particles.

7. The polishing composition of Claim 1, further comprises from 0.1 ppm to 0.5 wt. % of a compound selected from a polymer or copolymer comprising acrylic acid groups with molecular weight ranging between 500 and 100,000, a compound having a functional group selected from the group consisting of organic carboxylic acids, amino acids, amidocarboxylic acids, N-acylamino acids, and their salts thereof; organic sulfonic acids and salts thereof; organic phosphonic acids and salts thereof; polymeric carboxylic acids and salts thereof; polymeric sulfonic acids and salts thereof; polymeric phosphonic acids and salts thereof; arylamines, aminoalcohols, aliphatic amines, heterocyclic amines, hydroxamic acids, substituted phenols, sulfonamides, thiols, polyols having hydroxyl groups, and combinations thereof.

8. The polishing composition of Claim 1, further comprises a polymer or copolymer comprising acrylic acid groups with molecular weight ranging between 500 and 100,000.

9. The polishing composition of Claim 7, wherein the polymer or copolymer comprising acrylic acid groups is ammonium polyacrylate.

10. The polishing composition of Claim 1, further comprises at least one of
(1) an additive having a functional group selected from the group consisting of organic carboxylic acids and salts thereof, amino acids and salts thereof, amidocarboxylic acids and salts thereof, N-acylamino acids and salts thereof,

the abrasive particles are selected from the group consisting of fumed silica, colloidal silica, fumed alumina, colloidal alumina, cerium oxide, ceria-silica composite particles, titanium dioxide, zirconium oxide, polystyrene, polymethyl methacrylate, mica, hydrated aluminum silicate, and mixtures thereof; and

the compound to enhance removal rate of films comprising elemental silicon is selected from the group consisting of isothiazolinone and derivatives, thiazolinone and derivatives, imidazolidine and derivatives, pyrozolidine and derivatives, imidazole and derivatives, pyrazole and derivatives, thiazole and derivatives, isothiazole and derivatives, thiazolidine and derivatives, isothiazolidine and derivatives, dithiolane and derivatives, triazole and derivatives, tetrazole and derivatives, thiadiazole and derivatives, acetone, benzophenone, acetophenone, acetylacetone, butanol, 3-hydroxybutanal, p-nitrobenzenzaaldehyde, cinnamaldehyde, vanillin, and combinations thereof; and

polishing the at least one surface containing elemental silicon with the polishing composition.

12. The polishing method of Claim 11, wherein the compound to enhance removal rate of films comprising elemental silicon is selected from the group consisting of (i) isothiazolinone and derivative selected from the group consisting of methylisothiazolinone (MIT), chloromethylisothiazolinone (CMIT), benzisothiazolinone (BIT), octylisothiazolinone (OIT), dichlorooctylisothiazolinone (DCOIT), butylbenzisothiazolinone (BBIT), and combinations thereof; and (ii) thiazolinone and derivative selected from the group consisting of 2-Benzothiazol-1,1,3-trione (Saccharin), N-methyl 2-Benzothiazolinone, thiazolinone, and combinations thereof; and combinations thereof.

13. The polishing method of Claim 11, wherein the polishing composition comprises methylisothiazolinone (MIT); the liquid carrier is water; and the pH of the polishing composition is between 4 and 10.

14. The polishing method of Claim 11, wherein the semiconductor substrate further comprises at least one surface containing silicon oxide, silicon nitride or combinations thereof; and the polishing composition further comprises from 0.1 ppm

to 0.5 wt. % of (i)a polyacrylic acid or its salts with molecular weight ranging between 500 and 100,000; (ii) an additive having a functional group selected from the group consisting of organic carboxylic acids and salts thereof, amino acids and salts thereof, amidocarboxylic acids and salts thereof, N-acylamino acids and salts thereof, organic sulfonic acids and salts thereof; organic phosphonic acids and salts thereof; polymeric carboxylic acids and salts thereof; polymeric sulfonic acids and salts thereof; polymeric phosphonic acids and salts thereof; arylamines, aminoalcohols, aliphatic amines, heterocyclic amines, hydroxamic acids, substituted phenols, sulfonamides, thiols, polyols having hydroxyl groups, and combinations thereof; or combinations of (i) and (ii);

wherein removal rate selectivity between elemental silicon and silicon oxide or silicon nitride is tunable between 0.1 to 110.

15. The polishing method of Claim 13, wherein the polishing composition comprises methylisothiazolinone (MIT); ammonium polyacrylate with molecular weight ranging between 500 and 100,000; the liquid carrier is water; and the pH of the polishing composition is between 4 and 10.

16. The polishing method of Claim 11, wherein the polishing composition further comprises at least one of

(1) a pH adjusting agent selected from the group consisting of sodium hydroxide, cesium hydroxide, potassium hydroxide, cesium hydroxide, ammonium hydroxide, quaternary organic ammonium hydroxide (e.g. tetramethylammonium hydroxide), salts of polyacrylic acid, citric acid, acetic acid, carbonic acid, bicine, tricine, Tris, 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid, N-cyclohexyl-3-aminopropanesulfonic acid, 3-(N-morpholino)propanesulfonic acid, and piperazine-N,N-bis(2-ethanesulfonic acid), and mixtures thereof; wherein the pH adjusting agent ranges from 0.0005 % to 1 wt. %;

(2) a surfactant selected from the group consisting of a). Non-ionic surface wetting agents; b). Anionic surface wetting agents; c). Cationic surface wetting agents; d). ampholytic surface wetting agents; and mixtures thereof; wherein the surfactant ranges from 0.001 wt.% to about 1wt. %; and

(3) biological growth inhibitors or preservatives to prevent bacterial and fungal growth during storage.

17. A system for chemical mechanical planarization a semiconductor substrate comprising at least one surface containing elemental silicon, comprising:
the semiconductor substrate;

a polishing pad; and

a polishing composition comprising:
abrasive particles ranging from 0.01 wt.% to 15 wt.%;
a compound to enhance removal rate of films comprising elemental silicon ranging from 0.001 wt.% to 0.5 wt.%; and
liquid carrier; and
pH of the polishing composition is between 2 and 12;
wherein
the abrasive particles are selected from the group consisting of fumed silica, colloidal silica, fumed alumina, colloidal alumina, cerium oxide, ceria-silica composite particles, titanium dioxide, zirconium oxide, polystyrene, polymethyl methacrylate, mica, hydrated aluminum silicate, and mixtures thereof; and
the compound to enhance removal rate of films comprising elemental silicon is selected from a group consisting of isothiazolinone and derivatives, thiazolinone and derivatives, imidazolidine and derivatives, pyrozolidine and derivatives, imidazole and derivatives, pyrazole and derivatives, thiazole and derivatives, isothiazole and derivatives, thiazolidine and derivatives, isothiazolidine and derivatives, dithiolane and derivatives, triazole and derivatives, tetrazole and derivatives, thiadiazole and derivatives, and combinations thereof; acetone, benzophenone, acetophenone, acetylacetone, butanol, 3-hydroxybutanal, p-nitrobenzenzaaldehyde, cinnamaldehyde, vanillin, and combinations thereof;
wherein the semiconductor substrate is in contact with the polishing composition and the pad.

18. The system of Claim 17, wherein the compound to enhance removal rate of films comprising elemental silicon is selected from a group consisting of (i) isothiazolinone and derivative selected from the group consisting of methylisothiazolinone (MIT),

chloromethylisothiazolinone (CMIT), benzisothiazolinone (BIT), octylisothiazolinone (OIT), dichlorooctylisothiazolinone (DCOIT), butylbenzisothiazolinone (BBIT), and combinations thereof; and (ii) thiazolinone and derivative selected from the group consisting of 2-Benzothiazol-1,1,3-trione (Saccharin), N-methyl 2-Benzothiazolinone, thiazolinone, and combinations thereof; and combinations thereof.

19. The system of Claim 17, wherein the polishing composition comprises methylisothiazolinone (MIT); the liquid carrier is water; and the pH of the polishing composition is between 4 and 10.

20. The system of Claim 17, wherein the semiconductor substrate further comprises at least one surface containing silicon oxide, silicon nitride or combinations thereof; and the polishing composition further comprises from 0.1 ppm to 0.5 wt. % of (i)a polyacrylic acid or its salts with molecular weight ranging between 500 and 100,000; (ii) an additive having a functional group selected from the group consisting of organic carboxylic acids and salts thereof, amino acids and salts thereof, amidocarboxylic acids and salts thereof, N-acylamino acids and salts thereof, organic sulfonic acids and salts thereof; organic phosphonic acids and salts thereof; polymeric carboxylic acids and salts thereof; polymeric sulfonic acids and salts thereof; polymeric phosphonic acids and salts thereof; arylamines, aminoalcohols, aliphatic amines, heterocyclic amines, hydroxamic acids, substituted phenols, sulfonamides, thiols, polyols having hydroxyl groups, and combinations thereof; or combinations of (i) and (ii);
wherein the system provides a tunable removal rate selectivity between elemental silicon and silicon oxide or silicon nitride between 0.1 to 110.

21. The system of Claim 20, wherein the polishing composition comprises methylisothiazolinone (MIT); ammonium polyacrylate with molecular weight ranging between 500 and 100,000; the liquid carrier is water; and the pH of the polishing composition is between 4 and 10.

22. The system of Claim 17, wherein the polishing composition further comprises at least one of