Claims

1. A chemical mechanical planarization (CMP) polishing composition, comprising

(1) 0.01 wt.% to 20 wt.% of composite particles, wherein the composite particles comprise silica core particles and ceria nanoparticles and the composite particles are ceria coated silica particles having a mean particle size less than 150 nm;
wherein the composite particles have a particle size distribution of D50/(D99-D50) ≤ 1.30; D99 is a particle size that 99 wt.% of the composite particles fall on and under, and D50 is a particle size that 50 wt.% of the composite particles fall on and under; and the composite particles have multiple peaks in a particle size distribution plot;

(2) water soluble solvent selected from the group consisting of water, a polar solvent and a mixture of water and polar solvent; wherein the polar solvent is selected from the group consisting of alcohol, ether, ketone, or other polar reagent;

(3)pH of the CMP polishing composition ranges from 2 to 12;

and

optionally

(4)0.0001 wt.% to 5 wt.% of a pH adjusting agent selected from the group consisting of sodium hydroxide, cesium hydroxide, potassium hydroxide, ammonium hydroxide, quaternary organic ammonium hydroxide, and combinations thereof;

(5)0.000001 wt.% to 5 wt.% of a chemical additive elected from the group consisting of a compound having a functional group selected from the group consisting of organic carboxylic acids, amino acids, amid carboxylic 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, amino alcohols, aliphatic amines, heterocyclic amines, hydroxamic acids, substituted phenols, sulfonamides, thiols, polyols having hydroxyl groups, and combinations thereof;

(6)0.0001 wt.% to 10 wt.% of 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;

(7)0.01 wt.% to 3.0 wt.% of chelators;

(8)corrosion inhibitor;

(9)oxidizer; and

(10)biological growth inhibitor.

2. The chemical mechanical planarization (CMP) polishing composition of Claim 1, wherein the composite particles have D50 between 20 nm and 200 nm.

3. The chemical mechanical planarization (CMP) polishing composition of Claim 1,
wherein the CMP polishing composition comprises the ceria coated silica particles; polyacrylate (molecular weight 16000-18000); and pH between 4 and 7.

4. The chemical mechanical planarization (CMP) polishing composition of Claim 1,
wherein the CMP polishing composition comprises the ceria coated silica particles having the particle size distribution of D50/(D99-D50) ≤ 1.30; polyacrylate (molecular weight 16000-18000); and pH between 4 and 7.

5. A polishing method for chemical mechanical planarization (CMP) of a semiconductor substrate comprising at least one surface having at least one oxide layer, comprising the steps of:
a) contacting the at least one oxide layer with a polishing pad;
b) delivering a CMP polishing composition comprising
1) 0.01 wt.% to 20 wt.% of composite particles, wherein the composite particles comprise silica core particles and ceria nanoparticles and the composite particles are ceria coated silica particles having a mean particle size less than 150 nm;
wherein the composite particles have a particle size distribution of D50/(D99-D50) ≤ 1.30; D99 is a particle size that 99 wt.% of the composite particles fall on and under, and D50 is a particle size that 50 wt.% of the composite particles fall on and under; and the composite particles have multiple peaks in a particle size distribution plot;
2) water soluble solvent selected from the group consisting of water, a polar solvent and a mixture of water and polar solvent; wherein the polar solvent is selected from the group consisting of alcohol, ether, ketone, or other polar reagent;
3) pH of the CMP polishing composition ranges from 2 to 12;
and
optionally
4) 0.0001 wt.% to 5 wt.% of a pH adjusting agent selected from the group consisting of sodium hydroxide, cesium hydroxide, potassium hydroxide, ammonium hydroxide, quaternary organic ammonium hydroxide, and combinations thereof;

5) 0.000001 wt.% to 5 wt.% of a chemical additive elected from the group consisting of a compound having a functional group selected from the group consisting of organic carboxylic acids, amino acids, amino carboxylic 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, amino alcohols, aliphatic amines, heterocyclic amines, hydroxamic acids, substituted phenols, sulfonamides, thiols, polyols having hydroxyl groups, and combinations thereof;
6) 0.0001 wt.% to 10 wt.% of 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;
7) 0.01 wt.% to 3.0 wt.% of chelators;
8) corrosion inhibitor;
9) oxidizer; and
10) biological growth inhibitor; and
c) polishing the at least one oxide layer with the CMP polishing composition.

6. The polishing method of Claim 5, wherein the CMP polishing composition comprises the ceria coated silica particles; polyacrylate (molecular weight 16000-18000); and pH between 4 and 7.

7. The polishing method of Claim 5, wherein the CMP polishing composition comprises the ceria coated silica particles having the particle size distribution of $D50/(D99-D50) \leq 1.30$; polyacrylate (molecular weight 16000-18000); and pH between 4 and 7.

8. The polishing method of Claim 5, wherein ratio of removal rate of TEOS to removal rate of high density plasma (HDP) silicon dioxide film is < 1.

9. A system for chemical mechanical planarization, comprising:
a semiconductor substrate comprising at least one surface having at least one oxide layer;
a polishing pad; and
a CMP polishing composition comprising

1) 0.01 wt.% to 20 wt.% of composite particles, wherein the composite particles comprise silica core particles and ceria nanoparticles and the composite particles are ceria coated silica particles having a mean particle size less than 150 nm;
wherein the composite particles have a particle size distribution of D50/(D99-D50) ≤ 1.30; D99 is a particle size that 99 wt.% of the composite particles fall on and under, and D50 is a particle size that 50 wt.% of the composite particles fall on and under; and the composite particles have multiple peaks in a particle size distribution plot;
2) water soluble solvent selected from the group consisting of water, a polar solvent and a mixture of water and polar solvent; wherein the polar solvent is selected from the group consisting of alcohol, ether, ketone, or other polar reagent;
3) pH of the CMP polishing composition ranges from 2 to 12;
and
optionally
4) 0.0001 wt.% to 5 wt.% of a pH adjusting agent selected from the group consisting of sodium hydroxide, cesium hydroxide, potassium hydroxide, ammonium hydroxide, quaternary organic ammonium hydroxide, and combinations thereof;
5) 0.000001 wt.% to 5.0 wt.% of a chemical additive elected from the group consisting of a compound having a functional group selected from the group consisting of organic carboxylic acids, amino acids, amino carboxylic 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, amino alcohols, aliphatic amines, heterocyclic amines, hydroxamic acids, substituted phenols, sulfonamides, thiols, polyols having hydroxyl groups, and combinations thereof;
6) 0.0001 wt.% to 10 wt.% of 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;
7) 0.01 wt.% to 3.0 wt.% of chelators;
8) corrosion inhibitor;
9) oxidizer; and
10) biological growth inhibitor;
wherein
the at least one oxide layer is in contact with the polishing pad and the polishing composition.

10. The system for chemical mechanical planarization of claim 9, wherein the CMP polishing composition comprises the ceria coated silica particles; polyacrylate (molecular weight 16000-18000); and pH between 4 and 7.

11. The system for chemical mechanical planarization of claim 9, wherein the CMP polishing composition comprises the ceria coated silica particles having the particle size distribution of D50/(D99-D50) ≤ 1.30, polyacrylate (molecular weight 16000-18000); and pH between 4 and 7.