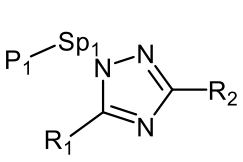
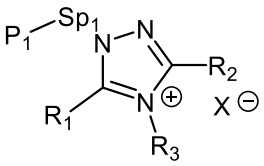
Claims

1. A chemical mechanical planarization composition comprising:
an abrasive selected from the group consisting of inorganic oxide particles, metal oxide-coated inorganic oxide particles, organic polymer particles, metal oxide-coated organic polymer particles, surface modified inorganic oxide particles, and combinations thereof;
an activator;
an oxidizing agent;
an additive comprising a triazole-based or triazolium-based polymer or copolymer;
water; and optionally
a corrosion inhibitor;
a dishing reducing agent;
a stabilizer;
a pH adjusting agent;
wherein the triazole-based or triazolium-based polymer or copolymer:
(1) is formed by at least one monomer having at least one triazole or triazolium group and comprising a structure selected from the group consisting of:



(A) ,



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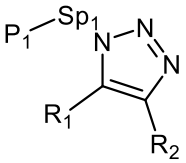
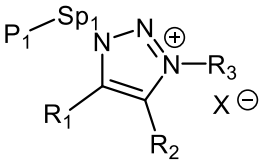


(C) ,and



(D) ;

wherein:
P_1 is a polymerizable group;
Sp_1 is a spacer group or a single bond;

R_1, R_2 is each independently selected from the group consisting of H, substituted or unsubstituted aliphatic, aromatic, heteroaromatic and siloxane moieties wherein CH_2 not in the aromatic or heteroaromatic ring may be replaced by O, S or N in a way that no heteroatoms are connected to each other and wherein hydrogen may be replaced by F, Cl or CN;

R_3 is a substituted or unsubstituted, linear, cyclic or branched aliphatic group; or

R_3 has a formula Q

$$-Sp_2-P_2 \quad (Q)$$

wherein:

Sp_2 is a spacer group or a single bond which can be the same or different from Sp_1; and is selected from the group consisting of a substituted or unsubstituted, linear, cyclic or branched aliphatic group wherein CH_2 may be replaced by O, S or N in a way that no heteroatoms are connected to each other and wherein hydrogen may be replaced by F, Cl or CN; and

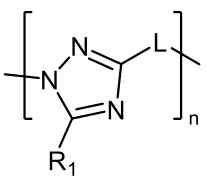
P_2 is a polymerizable group which can be the same or different from P_1; and is a group containing C=C double bonds;

and

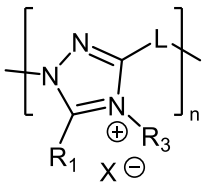
X^- is an anionic counterion;

or

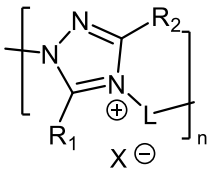
(2) has a repeating unit with a structure selected from the group consisting of:



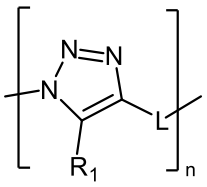
(F)



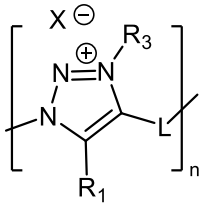
(G)



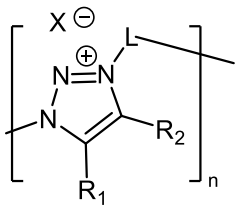
(H)



(I)



(J)



(K);

wherein:

L is a spacer group or a single bond;

R_1, R_2 and R_3 are each independently selected from the group consisting of H or substituted or unsubstituted aliphatic, aromatic, heteroaromatic or siloxane moieties wherein CH_2 not in the aromatic or heteroaromatic ring may be replaced by O, S or N in a way that no heteroatoms are connected to each other and wherein hydrogen may be replaced by F, Cl or CN;

n is an integer from 1 to 6000; and
X^- is an anionic counterion.

2. The chemical mechanical planarization composition of Claim 1, wherein the polymerizable group P_1 is selected from the group consisting of vinyl, styrene, acrylic or methacrylic, acrylamide, methacrylamide, ethylene glycol, vinyl ether, siloxane, phenol, norbornene type backbone, and combinations thereof, and preferably a group containing C=C double bonds.

3. The chemical mechanical planarization composition of Claim 1, wherein the spacer group or the single bond Sp_1 or L is selected from the group consisting of a substituted or unsubstituted, linear, cyclic or branched aliphatic group wherein CH_2 may be replaced by O, S or N in a way that no heteroatoms are connected to each other and wherein hydrogen may be replaced by F, Cl or CN.

4. The chemical mechanical planarization composition of Claim 1, wherein the anionic counterion X^- is selected from the group consisting of halide (F-, Cl-, Br-, or I-), BF_4-, PF_6-, carboxylate, malonate, citrate, carbonate, fumarate, $MeOSO_3$-, $MeSO_3$-, CF_3COO-, CF_3SO_3-, nitrate, and sulfate, wherein Me is methyl.

5. The chemical mechanical planarization composition of Claim 1, wherein the abrasive ranges from 0.01 wt.% to 30 wt.%, 0.05 wt.% to 20 wt.%, 0.01 wt.% to 10 wt.%, or from 0.1 wt.% to 2 wt.%.

6. The chemical mechanical planarization composition of Claim 1, wherein the additive comprising a triazole-based or triazolium-based polymer or copolymer ranges from 0.00001 wt.% to 1 wt.%, 0.0001 wt.% to 0.5 wt. %, 0.0002 wt.% to 0.1 wt.%, or 0.0005 wt.% to 0.05 wt.%.

7. The chemical mechanical planarization composition of Claim 1, wherein the oxidizing agent is selected from the group consisting of peroxy compound selected from the group consisting of hydrogen peroxide, urea peroxide, peroxyformic acid, peracetic acid, propaneperoxoic acid, substituted or unsubstituted butaneperoxoic acid, hydroperoxy-acetaldehyde, potassium periodate, ammonium peroxymonosulfate; and non-peroxy compound selected from the group consisting of ferric nitrite, $KClO_4$, $KBrO_4$, $KMnO_4$; and combinations thereof; and the oxidizing agent ranges from 0.01 wt.% to 30 wt.%, 0.1 wt.% to 20 wt.%, or 0.5 wt.% to 10 wt.%.

8. The chemical mechanical planarization composition of Claim 1, wherein the activator is selected from the group consisting of (1) inorganic oxide particle with transition metal coated onto its surface; and the transition metal is selected from the group consisting of Fe, Cu, Mn, Co, Ce, and combinations thereof; (2) soluble catalyst selected from the group consisting of iron(III) nitrate, ammonium iron(III) oxalate trihydrate, iron(III) citrate tribasic monohydrate, iron(III) acetylacetonate and ethylenediamine tetraacetic acid, iron(III) sodium salt hydrate; (3) a metal compound having multiple oxidation states selected from the group consisting of Ag, Co, Cr, Cu, Fe, Mo, Mn, Nb, Ni, Os, Pd, Ru, Sn, Ti, V; and combinations thereof; and the activator ranges from 0.00001 wt.% to 5.0 wt.%, 0.0001 wt.% to 2.0 wt.%, 0.0005 wt.% to 1.0 wt.%, or 0.001 wt.% to 0.5 wt.%.

9. The chemical mechanical planarization composition of Claim 1, wherein the corrosion inhibitor is selected from the group consisting of 1,2,3-triazole, 1,2,4-triazole, 1,2,3-benzotriazole, 5-methylbenzotriazole, benzotriazole, 1-hydroxybenzotriazole, 4-hydroxybenzotriazole, 3-amino-1,2,4-triazole, 4-amino-4H-1,2,4-triazole, 5 amino triazole, benzimidazole, 2,1,3-benzothiadiazole, triazinethiol, triazinedithiol, and triazinetrithiol, pyrazoles, imidazoles, isocyanurate such as 1,3,5-Tris(2-hydroxyethyl), and combinations thereof; and the corrosion inhibitor ranges from less than 1.0 wt.%, less than 0.5 wt.%, or less than 0.25 wt.%.

10. The chemical mechanical planarization composition of Claim 1, wherein the dishing reducing agent is selected from the group consisting of sarcosinate and related carboxylic compounds; hydrocarbon substituted sarcosinate; amino acids; organic polymers and copolymers having molecules containing ethylene oxide repeating units, such as polyethylene oxide (PEO); ethoxylated surfactants; nitrogen containing heterocycles without nitrogen-hydrogen bonds; sulfide; oxazolidine or mixture of

functional groups in one compound; nitrogen containing compounds having three or more carbon atoms that form alkylammonium ions; amino alkyls having three or more carbon atoms; polymeric corrosion inhibitor comprising a repeating group of at least one nitrogen-containing heterocyclic ring or a tertiary or quaternary nitrogen atom; polycationic amine compound; cyclodextrin compound; polyethyleneimine compound; glycolic acid; chitosan; sugar alcohols; polysaccharides; alginate compound; and sulfonic acid polymer; and combinations thereof; the preferred dishing reducing agent is glycine; and the dishing reducing agent ranges from 0.001 wt.% to 2.0 wt. %, 0.005 wt.% to 1.5 wt. %, or 0.01 wt.% to 1.0 wt. %.

11. The chemical mechanical planarization composition of Claim 1, wherein the stabilizer is selected from the group consisting of adipic acid, phthalic acid, citric acid, malonic acid, orthophthalic acid; phosphoric acid; substituted or unsubstituted phosphonic acids; nitriles; and combinations thereof; and the stabilizer ranges from 0.0001 to 5 wt.%, 0.00025 to 2 wt.%, or 0.0005 to 1 wt.%.

12. The chemical mechanical planarization composition of Claim 1, wherein pH of the composition is between 1 and 14, 1 and 7, 1 and 6, or 1.5 and 4.

13. The chemical mechanical planarization composition of Claim 1, wherein the abrasive is silica particles or surface modified silica particles.

14. The chemical mechanical planarization composition of Claim 1, wherein the triazole-based or triazolium-based polymer or copolymer comprises at least one selected from the group consisting of poly(vinyl-4-ethyl-1,2,4-triazol-4-ium) bromide, poly(vinyl-4-ethyl-1,2,4-triazol-4-ium-co-vinylpyrrolidone) bromide, poly(vinyl-1,2,4-triazole-co-vinylpyrrolidone) and poly(vinyl-4-ethyl-1,2,4-triazol-4-ium-co-vinyl-1,2,4-triazole) bromide.

15. The chemical mechanical planarization composition of Claim 1, wherein the chemical mechanical planarization composition comprises silica particles or surface modified silica particles; iron (III) nitrate, malonic acid, hydrogen peroxide, a triazole-based or triazolium-based polymer or copolymer comprises at least one selected from the group consisting of poly(vinyl-4-ethyl-1,2,4-triazol-4-ium) bromide, poly(vinyl-4-ethyl-1,2,4-triazol-4-ium-co-vinylpyrrolidone) bromide, poly(vinyl-1,2,4-triazole-co-vinylpyrrolidone),

and poly(vinyl-4-ethyl-1,2,4-triazol-4-ium-co-vinyl-1,2,4-triazole) bromide; and water; the pH of the composition is between 1.5 and 4.

16. The chemical mechanical planarization composition of Claim 1, wherein the triazole-based or triazolium-based polymer or copolymer is formed by a method selected from the group consisting of free radical polymerization, reversible addition-fragmentation chain-transfer polymerization (RAFT), nitroxide-mediated polymerization (NMP), atomic transfer reaction polymerization (ATRP), and polycondensation reaction.

17. The chemical mechanical planarization composition of Claim 1, wherein the triazole-based or triazolium-based copolymer has a block-copolymer character.

18. A polishing method for chemical mechanical planarization of a semiconductor substrate comprising at least one surface containing tungsten, comprising the steps of:
a) providing a polishing pad;
b) providing the chemical mechanical planarization composition according to any one of claims 1 to 17;
c) polishing the at least one surface containing tungsten with the chemical mechanical planarization composition;
wherein the semiconductor substrate optionally comprises at least one surface containing at least one of silicon nitride and silicon oxide.

19. The polishing method of Claim 18, wherein at least one surface containing tungsten comprises a dishing topography of less than 2000 or less than 1000 Angstroms and an erosion topography of less than 500 Angstroms.

20. The polishing method of Claim 18, wherein the semiconductor substrate comprises the at least one surface containing one of silicon nitride and silicon oxide, which comprises silicon nitride (Si_3N_4 or SiN), silicon oxide (SiO_2), and TiN; the removal selectivity of W vs SiN is ≥ 100; the removal selectivity of W vs SiO_2 is ≥ 60; and the removal selectivity of W vs TiN is ≥ 90; wherein the triazole-based or triazolium-based polymer or copolymer suppresses removal rate of TiN.

21. A system for chemical mechanical planarization of a semiconductor substrate comprising at least one surface containing tungsten, comprising:

a) a polishing pad; and

b) the chemical mechanical planarization composition according to any one of claims 1 to 17;

wherein the at least one surface containing tungsten is in contact with the polishing pad and the chemical mechanical planarization composition, thereby polishing the at least one surface containing tungsten with the chemical mechanical planarization composition.

22. A triazole-based or triazolium-based polymer or copolymer as defined in any one of Claims 1 to 4, 14, 16 or 17.