

Claims

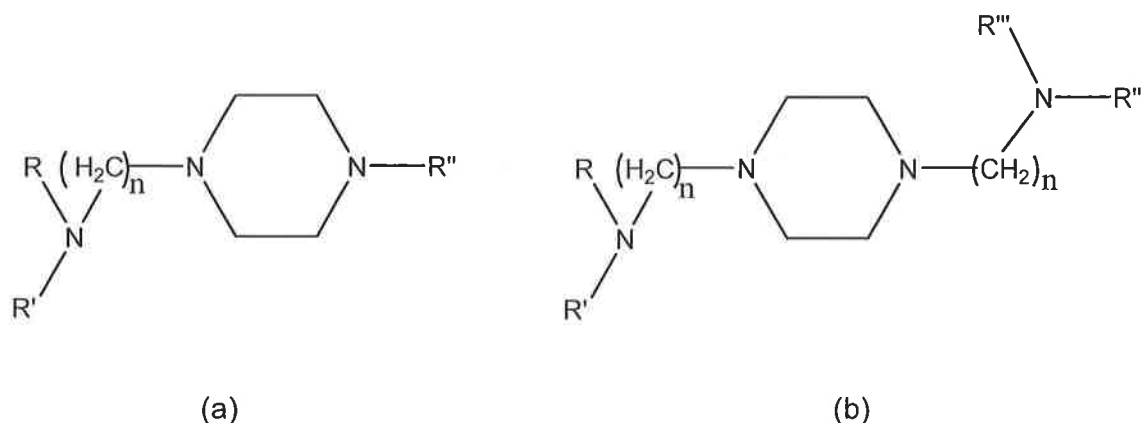
1. A tungsten chemical mechanical polishing (CMP) composition comprising:
- 5 a) 0.1 wt% to 25 wt% nano-sized abrasive selected from the group consisting of silica, alumina, ceria, titania, zirconia, and combinations thereof;
- b) 0.1 wt% to 0.5wt% solid catalyst of iron compound-coated particles selected from the group consisting of iron compound-coated colloidal silica, iron compound-coated colloidal inorganic metal oxide particles, iron compound-coated nano-sized inorganic metal oxide particles, and combinations thereof;
- 10 c) 0.0001 wt% to 0.5 wt% chemical additive which is a corrosion inhibitor selected from the group consisting of piperazine derivatives, salts of cyanate, and or combinations thereof;
- d) 0.5 wt % to 10 wt % oxidizer; and
- e) remaining is liquid carrier;
- 15 wherein pH of the CMP composition is from ~~about~~ 2.0 to ~~about~~ 8.0.; and

- ~~2. The tungsten chemical mechanical polishing (CMP) composition of Claim 1,~~
wherein the piperazine derivatives has have a general molecular structure of:



- 20 wherein R₁ and R₂ are independently selected from the group consisting of hydrogen, optionally substituted alkyl, optionally substituted aryl, optionally substituted aralkyl, optionally substituted alkoxy, optionally substituted organic group with one or more hydroxyl groups, optionally substituted organic sulfonic acid, optionally substituted organic sulfonic acid salt, optionally substituted keto,
- 25 optionally substituted organic carboxylic acid, optionally substituted organic carboxylic acid salt, optionally substituted organic carboxylic ester, optionally substituted organic amine and optionally substituted organic carboxylic amide.

32. The tungsten chemical mechanical polishing (CMP) composition of Claim 1, wherein the the piperazine derivative is optionally substituted organic mono-amino piperazine derivative (a) or optionally substituted organic bis-amino piperazine derivative (b) having molecular structures of:



wherein

n is independently selected from 1 to 6; and

- each R, R', R'' and R''' is independently selected from the group consisting of hydrogen, optionally substituted alkyl, optionally substituted aryl, optionally substituted aralkyl, optionally substituted alkoxy, optionally substituted organic group with one or more hydroxyl groups, optionally substituted organic sulfonic acid, optionally substituted organic sulfonic acid salt, optionally substituted keto, optionally substituted organic carboxylic acid, optionally substituted organic carboxylic acid salt, optionally substituted organic carboxylic ester, optionally substituted organic amine and optionally substituted organic carboxylic amide.

43. The tungsten chemical mechanical polishing (CMP) composition of Claim 1, wherein the piperazine derivative is selected from the group consisting of (R)-piperazine-2-carboxylic acid; 1-(2-Hydroxyethyl)piperazine; Piperazine-2,6-dione; 1-(2-Aminoethyl)piperazine; 1,4-Bis(2-hydroxyethyl)piperazine; 1,4-Bis(acryloyl)piperazine; Piperazine-1-acetic acid *tert*-butyl ester; 1-(3-Methylbenzyl)piperazine; 4-Boc-piperazine-2-carboxylic acid; 1-(Diphenylmethyl)piperazine; 1,4-Di-Boc-piperazine-2-carboxylic acid; 2-(piperazine-1-carbonyl)-benzoic acid; 4-(Piperazine-1-carbonyl)-piperidine-1-carboxylic acid *tert*-butyl ester; piperazine-1-carboxylic acid; (2-chloro-phenyl)-

piperazine; 4-(5-Carboxy-pyridin-2-yl)-2-methyl-piperazine-1-carboxylic acid *tert*-butyl ester; 4-Boc-1-(6-methyl-2-pyridyl)piperazine; Fmoc-4-carboxymethyl-piperazine; Methyl 4-Boc-piperazine-2-carboxylate; N,N-dimethyl-1-piperazine sulfonamide; *N*-1-Boc-*N*-4-Fmoc-2-Piperazine carboxylic acid; *N*-4-Boc-*N*-1-cbz-2-piperazine carboxylic acid; *N*-4-Boc-*N*-1-Fmoc-2-Piperazine acetic acid; sulfuric acid compound with piperazine-1-carboximidamide (1:1); 1-ethyl-4-piperidin-4-yl-piperazine; 1-furan-2-ylmethyl-piperazine; 1-methyl-4-(2-piperidin-4-yl-ethyl)-piperazine; 1-Methyl-4-(6-aminopyridin-3-yl)piperazine; 1-methyl-4-(piperidin-4-yl)-piperazine; 1-*N*-Boc-4-(azetidin-3-yl)piperazine; 1-pyridin-2-ylmethyl-piperazine; 1-Pyridin-3-ylmethyl-piperazine; 1-thiazol-2-yl-piperazine; 2-(2,5-dimethoxy-phenyl)-piperazine; 2-Carboxymethyl-3-oxo-piperazine-1-carboxylic acid *tert*-butyl ester; 2-Ethoxycarbonylmethyl-3-oxo-piperazine-1-carboxylic acid *tert*-butyl ester; 1-(4-methyl-cyclohexyl)-piperazine; 1-(4-methyl-piperidine-1-sulfonyl)-piperazine; 1-(4-trifluoromethyl-pyridin-2-yl)-piperazine; 1-(5-Methyl-2-pyridinyl)piperazine; 1-(5-Methyl-2-thiazolyl)-piperazine; 1-(5-Nitropyridin-2-yl)piperazine; 1-(6-Butoxy-2-pyridinyl)piperazine; 1-(6-methylpyrid-2-yl)piperazine; 1-(*N*-Methylpiperidin-3-yl-methyl)piperazine; 1-(thien-2-ylacetyl)piperazine; 1-Boc-4-(piperidin-4-yl)-piperazine; 1-Boc-4-cyanomethyl piperazine; 1-cyclohex-3-enylmethyl-piperazine, and combinations thereof.

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54. The tungsten chemical mechanical polishing (CMP) composition of Claim 1, wherein the piperazine derivative is selected from the group consisting of (*R*)-piperazine-2-carboxylic acid; 1-(2-Hydroxyethyl)piperazine; Piperazine-2,6-dione; 1-(2-Aminoethyl)piperazine; 1,4-Bis(2-hydroxyethyl)piperazine; 1,4-Bis(acryloyl)piperazine; Piperazine-1-acetic acid *tert*-butyl ester; 1-(3-Methylbenzyl)piperazine; 4-(Piperazine-1-carbonyl)-piperidine-1-carboxylic acid *tert*-butyl ester; piperazine-1-carboxylic acid diethylamide; piperazine-1-sulfonamide; piperazine-2-carboxamide; 1,2-dimethyl-piperazine; 2-isopropyl-piperazine; 1-(2-Pyrimidyl)piperazine; 1-(2-pyrazinyl)-piperazine; 1-(6-Pyridazinyl)piperazine; 1-(3-Hydroxyphenyl) piperazine; 1-(2-Pyridyl)piperazine; 1-(4-Methoxyphenyl)piperazine; 1-(4-Pyridyl)piperazine; 1-(4-Aminophenyl)piperazine; 1-(4-Methoxybenzyl)piperazine; 1-(2-Cyanophenyl)piperazine; 1-(2-Methoxyethyl)piperazine; 1-Boc-piperazine-2-carboxylic acid; 1-(2-Ethoxyethyl)piperazine; (*R*)-1-Boc-piperazine-2-carboxylic acid; (*R*)-3-

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N'-(4-butanesulfonic acid); 3-Methyl-2-ketopiperazine; HEPES potassium salt; 3-Piperazinopropionitrile; Ethyl piperazinoacetate; and combinations thereof.

65. The tungsten chemical mechanical polishing (CMP) composition of Claim 1, wherein
5 the piperazine derivative is selected from the group consisting of 1-(2-aminoethyl) piperazine, 1, 4-bis(3-aminopropyl)piperazine and combinations thereof.

76. The tungsten chemical mechanical polishing (CMP) composition of any one of the
preceding claims, wherein the chemical additive is or comprises salt of cyanate
10 selected from the group consisting of potassium cyanate, sodium cyanate, ammonium cyanate, alkylammonium cyanate, and combinations thereof.

87. The tungsten chemical mechanical polishing (CMP) composition of any one of the
preceding claims, further comprising one or more of
15 a corrosion inhibitor;
a pH buffering agent;
a surfactant; and
a biocide when pH of the polishing composition is from 5.0 to 8.0.

98. The composition of any one of the preceding claims, wherein the remainder of the
composition is substantially liquid carrier.

409. The composition of any one of the preceding claims wherein the nano-sized
abrasive is colloidal silica; the solid catalyst is ferric oxide-coated colloidal silica; the
25 chemical additive is 1-(2-aminoethyl)piperazine or potassium cyanate; the oxidizer is hydrogen peroxide; the corrosion inhibitor polyethylenimine is optionally present; and the remainder of the composition is deionized water.

4410. A process of selective chemical mechanical polishing, comprising the steps of:

- a) providing a semiconductor substrate having a surface containing tungsten and at least one other material;
- b) providing a polishing pad;
- c) providing a chemical mechanical polishing (CMP) composition as claimed in any
5 one of the preceding claims;
- d) contacting the surface of the semiconductor substrate with the polishing pad and the chemical mechanical polishing composition; and
- e) polishing the surface of the semiconductor substrate;

10 wherein at least a portion of the surface containing tungsten is in contact with both the polishing pad and the chemical mechanical polishing composition; and the ratio of removal rate of tungsten to removal rate of the at least one other material is equal or greater than 1.

15 ~~42~~11. A system of selective chemical mechanical polishing comprising:

- a) a polishing pad;
- b) a chemical mechanical polishing (CMP) composition as claimed in any
one of Claims 1-~~40~~9.

20 ~~43~~12. A system as claimed in Claim ~~42~~11, further comprising a semiconductor substrate having a surface containing tungsten and at least one other material; wherein at least a portion of the surface containing tungsten is in contact with both the polishing pad and the chemical mechanical polishing composition.

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