Claims

1. A stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion, wherein
the amino-polyorganosiloxane-coated abrasive particle has an aminofunctional polyorganosiloxane shell as its surface; wherein the aminofunctional polyorganosiloxane contains alkyl group having 1-6 carbon atoms.

2. The stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 1, wherein the amino-polyorganosiloxane-coated abrasive particle has a silanol density of <60%, or <50% SiOH/Si atom; and a positive charge of >15, or > 35 mV.

3. The stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 1, wherein the aminofunctional polyorganosiloxane shell has a thickness of 0.1 to 10 nm, or 0.5 to 5 nm.

4. A method of making a stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion comprising:
    a. providing aminosilane having a general formula of:
    $(A_xB_ySi)_z$-R; (I)
    wherein x and y each independent is 1 or 2 with x+y =3, and z is 1 or 2;
    A is a hydrolysable group selected from the group consisting of methoxy, and ethoxy, and combinations thereof;
    B is a non-hydrolyzable group selected from the group consisting of alkyl group having 1-6 carbon atoms, and phenyl; wherein B has no amino group;
    and R is a non-hydrolyzable group selected from the group consisting of aryl or alkyl group containing at least one amino group which can be primary, secondary, tertiary, or quaternary amino group;
    b. providing colloidal base abrasive particle dispersion wherein the base abrasive particle have reactive groups on its surface;
    c. adding the aminosilane to the colloidal base abrasive particle dispersion;
    d. forming the amino-polyorganosiloxane-coated abrasive particle by interacting aminosilane, its dimers, oligomers, and amino-

polyorganosiloxane (liner or cyclic) formed through the interactions among the aminosilane with the reactive groups on the surface of the base abrasive particle to form an aminofunctional polyorganosiloxane shell on the surface of the base abrasive;

wherein

the aminofunctional polyorganosiloxane shell has a thickness of 0.1 nm to 10 nm, or 0.5 to 5 nm; and covers or coats entire surface of the base abrasive particle; the amino-polyorganosiloxane-coated abrasive particle has a silanol density of <60%, or <50% SiOH/Si atom; and a positive charge of >15, or > 35 mV.

5. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the base abrasive particle is selected from the group consisting of colloidal silica, fumed silica, alumina, ceria, homogenous or gradient or core/shell particles, composite particles and combinations thereof; and the reactive groups on the surface of the base abrasive particle are Si-OH groups.

6. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein B in formula (I) is a methyl; R is selected from the group consisting of aminomethylene group, an aminoethylene group, an aminopropylene group, an aminoisopropylene group, an aminobutylene group, aminoethylaminopropyl group, and combinations thereof.

7. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the aminosilane is selected from the group consisting of n-(2-aminoethyl)-3-aminoisobutylmethyldimethoxysilane, n-(2-aminoethyl)-3-aminoisobutyldimethylmethoxysilane, (phenylaminomethyl)methyldimethoxysilane, n-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane, n-(2-aminoethyl)-3-aminopropylmethyldiethoxysilane**,** 3-(n,n-dimethylaminopropyl)aminopropylmethyldimethoxysilane, 3-aminopropyldiisopropylethoxysilane, 3-aminopropylmethyldiethoxysilane, 4-amino-3,3-dimethylbutylmethyldimethoxysilane, n,n-dimethyl-3-aminopropylmethyldimethoxysilane, n-methylaminopropylmethyldimethoxysilane,

3-aminopropyldimethylmethoxysilane, (phenylaminomethyl)methyldimethoxysilane, bis(methyldimethoxysilylpropyl)-n-methylamine, 4-aminobutyldimethylmethoxysilane, (4-aminobutyl) methyldiethoxysilane, and combinations thereof; and the amount of aminosilane is > 1, 2, or 3.0; and < 20, 15, or 10 weight% per g abrasive.

8. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the aminosilane is a methyl-substituted-derivative selected from the group consisting of aminopropyldimethoxymethylsilane, and aminopropyldimethylmethoxysilane; and the amount of aminosilane is > 1, 2, or 3.0; and < 20, 15, or 10 weight% per g abrasive.

9. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the aminosilane is (3-aminopropyl)dimethoxymethylsilane or (3-aminopropyl)(methoxy)dimethylsilane; the colloidal base abrasive particles are colloidal silica, and the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion is a stable colloidal amino-polyorganosiloxane-coated silica dispersion.

10. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the step a. further provides at least one of (a) co-reactant silane selected from the group consisting of (1)alkoxysilane and organically modified alkoxysilane with at least one and maximum two non-hydrolyzable substituent on the Si atom selected from the group consisting of methyl-, ethyl-, propyl-, and phenyl- group; and (2)silane with hydrolysable group selected from the group consisting of oximatosilanes, chlorosilanes, silazanes, oligosilazanes, and combinations thereof; wherein the co-reactant silane also interacts with the reactive groups on the surface of the base abrasive particle and aminosilane to form an aminofunctional polyorganosiloxane shell on the surface of the base abrasive particle; and ratio of amount of the aminosilanes vs the amount of the co-reactant silane is >1:99, or >1:30; and (b) at least one alkoxysilane selected from the group consisting of methoxysilanes, ethoxysilanes, propoxysilanes and the like; preferably tetraethyl

orthosilicate (TEOS), tetramethyl orthosilicate (TMOS), methyltriethoxysilane (MTEOS), methyltrimethoxysilane (MTMOS), dimethyldimethoxysilane; monomers of the alkoxysilane, and preformed oligomers of the alkoxysilane; wherein the reactant silane also interacts with the reactive groups on the surface of the base abrasive particle and aminosilane to form an aminofunctional polyorganosiloxane shell on the surface of the base abrasive particle and ratio of amount of the aminosilanes vs the amount of the co-reactant silane is >1:99, or > 1:30.

11. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the aminosilane has y=2 and z=1; the step a. further provides at least one alkoxysilane selected from the group consisting of methoxysilanes, ethoxysilanes, propoxysilanes and the like; preferably tetraethyl orthosilicate (TEOS), tetramethyl orthosilicate (TMOS), methyltriethoxysilane (MTEOS), methyltrimethoxysilane (MTMOS), dimethyldimethoxysilane; monomers of the alkoxysilane, and preformed oligomers of the alkoxysilane; wherein the reactant silane also interacts with the reactive groups on the surface of the base abrasive particle and aminosilane to form an aminofunctional polyorganosiloxane shell on the surface of the base abrasive particle and ratio of amount of the aminosilanes vs the amount of the co-reactant silane is >1:99, or > 1:30.

12. The method of making stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4, wherein the colloidal base abrasive particles are colloidal silica; the aminosilane is (3-aminopropyl)(methoxy)dimethylsilane; the step a. further provides methyltriethoxysilane; ratio of amount of (3-aminopropyl)(methoxy)dimethylsilane vs amount of methyltriethoxysilane is >1:50, 1:40, or >1:30; and the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion is a stable colloidal amino-polyorganosiloxane-coated silica dispersion.

13. A chemical mechanical polishing (CMP) composition comprises:
the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 1;

water-soluble solvent; and

optionally at least one of:

organic and inorganic salt as colloidal stabilizer;

acid/base buffer agent;

biocide;

oxidizer;

catalyst;

corrosion inhibitor;

organic polymers as erosion, dishing and corrosion reducer; wherein example polymers include but are not limited to hydrophilic polymers, polymers with organic functional groups like -OH, $-NR_1R_2R_3R_4$ (with R_{1-4} being independently either H, alkyl, aryl), CN -, ester, amide, halogen, ether,

inorganic polymers for like mono-metal- or mixed-metal polymetalhydroxide clusters, polyanions, polycations, especially those containing Al, Ce, Zr, Fe as metal ions;

surface-active molecules/oligomers/polymers like cationic-, anionic- or nonionic surfactants and polymers which attach by either physical adsorption, ionic or covalent bonding;

wherein the CMP composition has a pH of 2 to 10, or 2 to 8.

14. A chemical mechanical polishing (CMP) method comprises:

providing a substrate having at least one surface comprising tungsten;

providing a chemical mechanical polishing (CMP) composition comprises:

the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 1;

water-soluble solvent; and

optionally at least one of:

organic and inorganic salt as colloidal stabilizer;

acid/base buffer agent;

biocide;

oxidizer;

catalyst;

corrosion inhibitor;

organic polymers as erosion, dishing and corrosion reducer; wherein example polymers include but are not limited to hydrophilic polymers, polymers with organic functional groups like -OH, $-NR_1R_2R_3R_4$ (with R_{1-4} being independently either H, alkyl, aryl), CN -, ester, amide, halogen, ether,

inorganic polymers for like mono-metal- or mixed-metal polymetalhydroxide clusters, polyanions, polycations, especially those containing Al, Ce, Zr, Fe as metal ions;

surface-active molecules/oligomers/polymers like cationic-, anionic- or nonionic surfactants and polymers which attach by either physical adsorption, ionic or covalent bonding;

wherein the CMP composition has a pH of 2 to 10, or 2 to 8;

contacting the surface of the semiconductor substrate with the polishing pad and the chemical mechanical polishing composition; and

polishing the least one surface comprising tungsten.

15. The chemical mechanical polishing (CMP) method of claim 14, wherein the surface of the semiconductor substrate further comprises silicon dioxide film; and removal selectivity of W: SiO_2 is greater than 30, or 120.

16. A chemical mechanical polishing (CMP) system comprises:

a polishing pad;

a substrate having at least one surface comprising tungsten;

a chemical mechanical polishing (CMP) composition comprises:

the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 1;

water-soluble solvent; and

optionally at least one of:

organic and inorganic salt as colloidal stabilizer;

acid/base buffer agent;

biocide;

oxidizer;

catalyst;

corrosion inhibitor;

organic polymers as erosion, dishing and corrosion reducer; wherein example polymers include but are not limited to hydrophilic polymers, polymers with organic functional groups like -OH, $-NR_1R_2R_3R_4$ (with R_{1-4} being independently either H, alkyl, aryl), CN -, ester, amide, halogen, ether,

inorganic polymers for like mono-metal- or mixed-metal polymetalhydroxide clusters, polyanions, polycations, especially those containing Al, Ce, Zr, Fe as metal ions;

surface-active molecules/oligomers/polymers like cationic-, anionic- or nonionic surfactants and polymers which attach by either physical adsorption, ionic or covalent bonding;

wherein the CMP composition has a pH of 2 to 10, or 2 to 8;

wherein the surface of the semiconductor substrate is in contact with the polishing pad and the chemical mechanical polishing composition.

17. The chemical mechanical polishing (CMP) system of claim 16, wherein the surface of the semiconductor substrate further comprises silicon dioxide film; and removal selectivity of W: SiO_2 is greater than 50, or 120.

18. The stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 1, wherein the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion is a stable colloidal amino-polyorganosiloxane-coated silica dispersion.

19. The chemical mechanical polishing (CMP) composition of claim 13, wherein the amino-polyorganosiloxane-coated abrasive particle has a silanol density of <60%, or <50% SiOH/Si atom; and a positive charge of >15, > 25, or > 35 mV; and the aminofunctional polyorganosiloxane shell of the amino-polyorganosiloxane-coated abrasive particle has a thickness of 0.1 to 10 nm, or 0.5 to 5 nm.

20. The chemical mechanical polishing (CMP) composition of claim 13, wherein the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion is a stable colloidal amino-polyorganosiloxane-coated silica dispersion.

21. The chemical mechanical polishing (CMP) system of claim 16, wherein the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion is a stable colloidal amino-polyorganosiloxane-coated silica dispersion.

22. A chemical mechanical polishing (CMP) composition comprises:
the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion of claim 4;
water-soluble solvent; and
optionally at least one of:
organic and inorganic salt as colloidal stabilizer;
acid/base buffer agent;
biocide;
oxidizer;
catalyst;
corrosion inhibitor;
organic polymers as erosion, dishing and corrosion reducer; wherein example polymers include but are not limited to hydrophilic polymers, polymers with organic functional groups like -OH, $-NR_1R_2R_3R_4$ (with R_{1-4} being independently either H, alkyl, aryl), CN -, ester, amide, halogen, ether,
inorganic polymers for like mono-metal- or mixed-metal polymetalhydroxide clusters, polyanions, polycations, especially those containing Al, Ce, Zr, Fe as metal ions;
surface-active molecules/oligomers/polymers like cationic-, anionic- or nonionic surfactants and polymers which attach by either physical adsorption, ionic or covalent bonding;
wherein the CMP composition has a pH of 2 to 10, or 2 to 8.

23. The chemical mechanical polishing (CMP) composition of claim 22, wherein the amino-polyorganosiloxane-coated abrasive particle has a silanol density of <60%, or <50% SiOH/Si atom; and a positive charge of >15, > 25, or > 35 mV; and the aminofunctional polyorganosiloxane shell of the amino-polyorganosiloxane-coated abrasive particle has a thickness of 0.1 to 10 nm, or 0.5 to 5 nm.

24. The chemical mechanical polishing (CMP) composition of claim 22, wherein the stable colloidal amino-polyorganosiloxane-coated abrasive particle dispersion is a stable colloidal amino-polyorganosiloxane-coated silica dispersion.