Claims

1. Colloidally stable amphiphilic abrasive particles, wherein surface of each colloidally stable amphiphilic abrasive particle comprises hydrophilic moieties and hydrophobic moieties,

   wherein each of the hydrophilic moieties preferably independently comprises at least one selected from the group consisting of a N-containing group selected from the group comprising amine and substituted amines; amino group; ammonium; ammonium group and substituted ammonium group; sulfonium; phosphonium; sulfate; sulfonate; phosphate; hydroxy; epoxy; carboxy; ether; polyether; and polyether groups; and/or

   each of the hydrophobic moieties independently preferably comprises at least one selected from the group consisting of alky group having < 20 C atoms, < 10 C atoms, or < 4 C atoms; and aryl has < 20 C atoms, < 10 C atoms, or < 8 C atoms; and/or

   the surface of each of the colloidally stable amphiphilic abrasive particles is preferably a covalently bonded polymeric crosslinked shell; or

   the surface of each of the colloidally stable amphiphilic abrasive particles is preferably a covalently bonded polyorganosiloxane crosslinked shell.

2. The colloidally stable amphiphilic abrasive particles according to claim 1, wherein each of the hydrophilic moieties independently comprises at least one selected from the group consisting of amine, ammonium, and alkylammonium group comprising alkyl having < 20 C atoms; < 10 C atoms or < 4 C atoms; and/or

   each of the hydrophobic moieties independently comprises at least one selected from the group consisting of methyl, ethyl, propyl, butyl, phenyl, benzyl, tolyl, and xylyl group.

3. The colloidally stable amphiphilic abrasive particles according to claim 1 or 2, wherein more than one hydrophilic moieties and/or more than one hydrophobic moieties can be attached to a linking atom selected from the group consisting of

Si, Ce, Al, Zr, C, P, and N atoms; wherein the linking atom links or bonds hydrophilic moieties and/or hydrophobic moieties to the surface of each colloidally stable amphiphilic abrasive particle through covalent bonds; and/or

the hydrophilic moieties are silanes having amino-groups; and
the hydrophobic moieties are trimethylsilane-groups; and/or

a ratio of hydrophilic moieties vs. the hydrophobic moieties ranges from 1.00 : 0.01 to 1.00 : 10.00, 1.00 : 0.25 to 1.00 : 5:00, 1.00 : 0.30 to 1.00 : 3:00, 1.00 : 0.40 to 1.00 : 2.50, or 1.00 : 0.50 to 1.00 : 2.00; and/or

the colloidally stable amphiphilic abrasive particles have a highly unpolar and inert surface towards silicon oxide.

4. A method of making colloidally stable amphiphilic abrasive particles comprising:
    a. providing base abrasive particles having reactive M-OH groups on their surfaces and the base abrasive particles are dispersed in a solvent;
    b. modifying the surfaces of the base abrasive particles with a first step surface modifier having at least one hydrophilic group and at least one first reactive group capable to form a covalent bond with the reactive M-OH groups to obtain one-step modified abrasive particles;
    c. modifying surface of the one-step modified abrasive particles with a second step surface modifier having at least one hydrophobic group and having at least one second reactive group capable to form a covalent bond with reactive X-OH groups on surfaces of the one-step modified abrasive particles to obtain the amphiphilic abrasive particles; and, optionally,
    d. keeping water as only dispersion after the second step surface modification;

    wherein the first step surface modifier is preferably selected from silanes having the at least one hydrophilic group and the second step surface modifier is preferably selected from silanes having the at least one hydrophobic group; and/or

the first step surface modifier is preferably capable to react among themselves to form a covalently bonded polymeric crosslinked shell around the base abrasive particle; and/or

the second step surface modifier comprises silanes having at least two, preferably at least three hydrophobic groups comprising alkyl with < 20 C atoms, < 10 C atoms or < 4 C atoms; or aryl with < 20 C atoms, < 10 C atoms, or < 8 C atoms; and/or

wherein the second step surface modifier preferably does not carry a functional group on the hydrophobic group of alkyl- or aryl group; and/or

the at least one first reactive group or the at least one second reactive group is preferably independently selected from the group consisting of Si-alkoxides, Si-halogenides, more preferably chlorides, oximates, acetates, Si-hydroxides; and combinations thereof; particularly preferably siliciummethoxides and siliciumethoxides; and/or

a ratio of the first step modifier and the reactant is preferably in a range of 9.9 : 1 to 0.1 : 9.9, more preferably 9:1 to 1:9;

wherein

the M in the reactive M-OH groups is selected from the group consisting of Si, Ce, Al, Zr, hybrids and/or mixtures thereof;
the X in the reactive X-OH groups is selected from the group consisting of Si, Ce, Al, Zr, C, P, N, hybrids and/or mixtures thereof; and
the solvent is selected from the group consisting of water,
alcohol, preferably ethanol, isopropanol or n-propanol,
ketone, preferably acetone,
ester, preferably propylenglycolmonoacetylester, ether, preferably diethylether, propylenglycoldimethylether or propylenglycolmonomethylether,
glycol, and combinations thereof;
more preferably combinations of water and alcohol.

5. The method of making colloidally stable amphiphilic abrasive particles according to claim 4, wherein the at least one hydrophilic group comprises at least one selected from the group comprising a N-containing group selected from the group comprising amines and substituted amines; amino group; ammonium; ammonium group and substituted ammonium group which includes but is limited to alkylammonium group comprising alkyl having < 20 C atoms, < 10 C atoms or < 4 C atoms; sulfonium; phosphonium; sulfate; sulfonate; phosphate; hydroxy; epoxy; carboxy; ether; polyether; or polyether groups; preferably a N-containing group selected from the group comprising amine, amino group, ammonium, and alkylammonium group; and/or

   the at least one hydrophobic group comprises at least one selected from the group consisting of alky group having < 20 C atoms, < 10 C atoms, or < 4 C atoms; and aryl has < 20 C atoms, < 10 C atoms, or < 8 C atoms.

6. The method of making colloidally stable amphiphilic abrasive particles according to claim 4 or 5, wherein the at least one hydrophilic group comprises at least one selected from the group consisting of amine, ammonium, and alkylammonium group comprising alkyl having < 20 C atoms; < 10 C atoms or < 4 C atoms; and/or

   wherein the at least one hydrophobic group consists of at least one selected from the group consisting of methyl, ethyl, propyl, butyl, phenyl, benzyl, tolyl, and xylyl.

7. The method of making colloidally stable amphiphilic abrasive particles according to any one of claims 4-6, wherein total amount of the first step surface modifiers and the second step surface modifiers ranges from 0.01 –1.0 mmol/g (mass of abrasives calculated as dry matter), 0.025-0.8 mmol/g, 0.05 – 0.5 mmol/g, or 0.1 – 0.4 mmol/g.

8. The method of making colloidally stable amphiphilic abrasive particles according to any one of claims 4-7, wherein the base abrasive particle is selected from the

group consisting of colloidal silica, fumed silica, alumina, ceria, and combinations thereof.

9. The method of making colloidally stable amphiphilic abrasive particles according to any one of claim 4-8, wherein the first step surface modifiers is selected from the group consisting of amino-polyether silanes, betain-type silanes, 3-aminopropyl- derivatives of ethoxy- or methoxysilanes, preferably 3-aminopropylmethyldimethoxysilane; and combinations thereof; and/or

   the second step surface modifier is selected from the group consisting of trimethylmethoxysilane, trimethylethoxysilane, dimethylphenylmethoxysilane, diphenylsilanediol, diphenyldimethoxysilane, methylphenyldimethoxysilane, dimethyldimethoxysilane, hexamethyldisilazane, hexamethyldisiloxane, dimethylethylmethoxysilane, dimethyloctylmethoxysilane, dimethyloctadecylchlorosilane, dimethylhexadecylmethoxysilane, dimethyl(methylphenyl)methoxysilane, potassium-trimethylsilanoate, triethylmethoxysilane, and combinations thereof.

10. The method of making colloidally stable amphiphilic abrasive particles according to any one of claims 4-9, wherein the first step surface modifiers is 3-aminopropylmethyldimethoxysilane; and the second step surface modifier is selected from the group consisting of trimethylmethoxysilane, trimethylethoxysilane, and combinations thereof; and/or

    the solvent is selected from the group consisting of water, ethanol, and combinations thereof.

11. The method of making colloidally stable amphiphilic abrasive particles according to any one of claims 4-10, wherein the first step surface modifiers can be used in combination with a reactant selected from the group consisting of tetramethoxysilane, tetraethoxysilane, methyltrimethoxysilane, methyltriethoxysilane, and combinations thereof; and ratio of the first step modifier and the reactant ranges from 9.9 : 1 to 0.1 : 9.9; preferably 9:1 to 1:9.

12. Colloidally stable amphiphilic abrasive particles made according to any one of claims 4 to 11.

13. A chemical mechanical polishing (CMP) composition comprises:
colloidally stable amphiphilic abrasive particles according to any one of claims 1 to 3 or claim 12; and
solvent;
optionally comprise at least one of:
organic and inorganic salt as colloidal stabilizer;
catalyst including but is not limited to fluoride ions, metal salts or metal alkoxides like titaniumisopropoxide;
acid/base pH buffer agent;
biocide;
oxidizer;
catalyst; and
corrosion inhibitor;
wherein
the solvent is selected from the group consisting of water; water soluble solvent selected from the group consisting of alcohol, ether, and ketone; and combinations thereof; and
the CMP composition has a pH of 2 to 10, 2 to 8, 2 to 6, 2 to 5, 2 to 4, or 2 to 3.

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:
colloidally stable amphiphilic abrasive particles according to any one of claims 1 to 3 or claim 12; and
water-soluble solvent;
wherein the CMP composition has a pH of 2 to 10, 2 to 8, 2 to 6, 2 to 5, 2 to 4, or 2 to 3;
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;

wherein the surface of the semiconductor substrate preferably further comprises silicon dioxide film; and removal selectivity of W: SiO_2 is greater than 80, 100, 150, or 200.

15. 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:
        colloidally stable amphiphilic abrasive particles according to any one of claims 1 to 3 or claim 12; and
        water-soluble solvent;
        wherein the CMP composition has a pH of 2 to 10, 2 to 8, 2 to 6, 2 to 5, 2 to 4, or 2 to 3;
    wherein the surface of the semiconductor substrate with the polishing pad and the chemical mechanical polishing composition so the tungsten can be polished; and

    wherein the surface of the semiconductor substrate preferably further comprises silicon dioxide film; and removal selectivity of W: SiO2 is greater than 80, 100, 150, or 200.