CLAIM(S):

What is claimed is:

~~1. A chemical mechanical polishing composition comprising:~~

~~a water based liquid carrier;~~

~~colloidal silica abrasive particles dispersed in the liquid carrier;~~

~~a chemical species incorporated in the colloidal silica abrasive particles internal to an outer surface thereof, wherein the chemical species is a nitrogen containing compound or a phosphorus containing compound;~~

~~a pH in a range from about 3.5 to about 6;~~

~~wherein the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV; and~~

~~wherein the chemical species is not an aminosilane or a phosphonium silane.~~

~~2. A chemical mechanical polishing composition comprising:~~

~~a water based liquid carrier;~~

~~colloidal silica abrasive particles dispersed in the liquid carrier;~~

~~a chemical species incorporated in the colloidal silica abrasive particles internal to an outer surface thereof, wherein the chemical species is a nitrogen containing compound or a phosphorus containing compound;~~

~~a pH in a range from about 1.5 to about 7;~~

~~wherein the colloidal silica abrasive particles have a permanent positive charge of at least 13 mV; and~~

~~wherein an aminosilane compound is bonded with the outer surface of the colloidal silica abrasive particles.~~

~~3. The composition of any one of claims 1-2, wherein the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV.~~

~~4. The composition of any one of claims 2-3, having a pH in a range from about 3.5 to about 6.~~

~~5. The composition of any one of claims 1-4, further comprising a buffering agent having a pKa in a range from about 3.5 to about 5.5.~~

~~6. The composition of any one of claims 1-5, wherein the colloidal silica abrasive particles have a mean particle size in a range from about 30 to about 70 nm.~~

~~7. The composition of any one of claims 1-5, wherein the colloidal silica abrasive particles have a mean particle size in a range from about 40 to about 60 nm.~~

~~8. The composition of any one of claims 1-7, comprising from about 0.5 to about 4 weight percent of the colloidal silica abrasive particles.~~

~~9. The composition of any one of claims 1-7, comprising less than about 3 weight percent of the colloidal silica abrasive particles.~~

~~10. The composition of any one of claims 1-9, wherein 30 percent or more of the colloidal silica abrasive particles include three or more aggregated primary particles.~~

~~11. The composition of any one of claims 1-9, wherein 50 percent or more of the colloidal silica abrasive particles include three or more aggregated primary particles and 20 percent or more of the colloidal silica abrasive particles are monomers or dimers.~~

~~12. The composition of any one of claims 1-11, wherein the colloidal silica abrasive particles include primary particles and 95 percent or more of the primary particles have a primary particle size in a range from 15 to 35 nm.~~

~~13. The composition of any one of claims 1-12, wherein the chemical species is not ammonium.~~

~~14. The composition of any one of claims 1-13, wherein the chemical species comprises a primary amine, a secondary amine, a tertiary amine, or a quaternary amine compound.~~

~~15. The composition of any one of claims 1-13, wherein the chemical species comprises an amino acid.~~

~~16. The composition of any one of claims 1-13, wherein the chemical species comprises from 1 to 6 carbon atoms.~~

~~17. The composition of claim 16, wherein the chemical species comprises ethyloxypropylamine, tetramethyl ammonium hydroxide, or ethylenediamine.~~

~~18. The composition of any one of claims 1-17, wherein the colloidal silica abrasive particles have a core-shell structure in which an outer shell is disposed over an inner core, the chemical species being incorporated in the outer shell.~~

~~19. The composition of claim 18, wherein the outer shell has a thickness of at least 1 nm.~~

~~20. The composition of any one of claims 1-19, having an electrical conductivity of less than about 300 μS/cm.~~

~~21. The composition of any one of claims 1-20, wherein the colloidal silica has a density of greater than 1.90 g/cm^3.~~

~~22. The composition of claim 1, wherein:~~

~~the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV;~~

~~the composition has a pH in a range from about 3.5 to about 6;~~

~~the colloidal silica abrasive particles have a mean particle size in a range from about 30 to about 70 nm; and~~

the composition includes from about 0.5 to about 4 weight percent of the colloidal silica abrasive particles.

23. The composition of claim 1, wherein:

the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV;

the composition further includes a buffering agent having a pKa in a range from about 3.5 to about 5.5;

the composition includes from about 0.5 to about 4 weight percent of the colloidal silica abrasive particles;

the colloidal silica has a density of greater than 1.90 g/cm^3; and

the chemical species comprises from 1 to 6 carbon atoms.

24. The composition of claim 1, wherein:

the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV;

the composition further includes a buffering agent having a pKa in a range from about 3.5 to about 5.5;

the composition includes from about 0.5 to about 4 weight percent of the colloidal silica abrasive particles;

30 percent or more of the colloidal silica abrasive particles include three or more aggregated primary particles; and

the chemical species comprises from 1 to 6 carbon atoms.

25. The composition of claim 1, wherein:

the composition comprises less than 4 weight percent of the colloidal silica abrasive particles;

the colloidal silica has a density of greater than 1.90 g/cm^3;

30 percent or more of the colloidal silica abrasive particles include three or more aggregated primary particles; and

the colloidal silica abrasive particles include 0.20 or more weight percent nitrogen.

~~26. The composition of claim 1, wherein:~~

~~the colloidal silica abrasive particles have a mean particle size in a range from about 30 to about 70 nm;~~

~~30 percent or more of the colloidal silica abrasive particles include three or more aggregated primary particles; and~~

~~the colloidal silica abrasive particles include primary particles and 95 percent or more of the primary particles have a primary particle size in a range from 15 to 35 nm.~~

~~27. The polishing composition of claim 2, wherein:~~

~~the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV;~~

~~the chemical species comprises from 1 to 6 carbon atoms;~~

~~30 percent or more of the colloidal silica abrasive particles include three or more aggregated primary particles; and~~

~~the colloidal silica abrasive particles have a mean particle size in a range from about 30 to about 70 nm.~~

~~28. The composition of any one of claims 2-21 and 27, wherein the aminosilane compound is bonded with less than 4% of silanol groups on the outer surface of the colloidal silica particles.~~

~~29. The composition of any one of claims 2-21 and 27-28, wherein the colloidal silica abrasive particles include less than 0.20 weight percent nitrogen.~~

~~30. The composition of any one of claims 1-29, further comprising a silicon nitrogen polishing accelerator including a polycarboxylic acid, a poly phosphonic acid, or a mixture thereof.~~

~~31. The composition of claim 30, wherein the polycarboxylic acid comprises oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, tartaric acid, citric acid, phthalic acid, sulfosuccinic acid, or a mixture thereof.~~

~~32. The composition of one of claims 30 and 31, wherein the poly phosphonic acid comprises a diphosphonic acid compound or a methylene phosphonic acid compound.~~

~~33. The composition of any one of claims 1-32, further comprising a silicon nitrogen polishing inhibitor having a ring and a nitrogen atom in or bonded to the ring.~~

~~34. The composition of claim 33, wherein the inhibitor further comprises a hydroxy group bonded to the ring.~~

~~35~~1. A method of chemical mechanical polishing a substrate including a silicon oxygen containing material, the method comprising:

(a) contacting the substrate with the chemical mechanical polishing composition comprising:

a water based liquid carrier;

colloidal silica abrasive particles dispersed in the liquid carrier;

a chemical species incorporated in the colloidal silica abrasive particles internal to an outer surface thereof, wherein the chemical species is a nitrogen containing compound or a phosphorus containing compound;

a pH in a range from about 3.5 to about 6;

wherein the colloidal silica abrasive particles have a permanent positive charge of at least 15 mV; and

wherein the chemical species is not an aminosilane or a phosphonium silane~~of any one of claims 1-34~~;

(b) moving the polishing composition relative to the substrate; and

(c) abrading the substrate to remove a portion of the silicon oxygen containing material from the substrate and thereby polish the substrate.

~~36~~2. The method of claim ~~35~~1, wherein:

the polishing composition comprises less than 4 percent by weight of the colloidal silica abrasive particles; and

an average removal rate of the silicon oxygen material in (c) is greater than 3000 Å/min at a downforce of 5 psi or less.

~~37~~3. The method of ~~any one of~~ claim~~s~~ ~~35~~1~~-36~~, wherein:

the polishing composition comprises less than 2 percent by weight of the colloidal silica abrasive particles; and

an average removal rate of the silicon oxygen material in (c) is greater than 3000 Å/min at a downforce of 5 psi or less.

~~38~~4. The method of ~~any one of~~ claim~~s~~ ~~35~~1~~-37~~, wherein:

the polishing composition comprises less than 3 percent by weight of the colloidal silica abrasive particles; and

an average removal rate of the silicon oxygen material in (c) is greater than 2000 Å/min at a downforce of 4 psi or less.

~~39~~5. The method of ~~any one of~~ claim~~s~~ ~~35~~1~~-38~~, wherein:

the polishing composition comprises less than 2.0 percent by weight of the colloidal silica abrasive particles; and

an average removal rate of the silicon oxygen material in (c) is greater than 2000 Å/min at a downforce of 4 psi or less.

~~40~~6. The method ~~of any one~~ of claim~~s~~ ~~35~~1~~-39~~, wherein:

the polishing composition comprises less than 2.5 percent by weight of the colloidal silica abrasive particles; and

a removal rate of the silicon oxygen material in (c) is greater than 2000 Å/min at a down force of 4 psi or less and a removal rate of a silicon nitride material is less than 300 Å/min at a downforce of 3 psi or less.

~~41~~7. The method of ~~any one of~~ claim~~s~~ ~~35~~1~~-39~~, wherein the polishing composition further comprises a silicon nitrogen polishing accelerator and a TEOS:SiN polishing rate selectivity is less than about 10:1.

~~42~~8. The method of ~~any one of~~ claim~~s~~ ~~35~~1~~-39~~, wherein the polishing composition further comprises a silicon nitrogen polishing inhibitor and a TEOS:SiN polishing rate selectivity is greater than about 25:1.