particular, ether solvents can penetrate the porous low-k dielectric layer thereby increasing the layer's dielectric constant. Thus, ether solvents can contaminate the porous low-k layer and adversely affect its insulation ability. In addition, ether solvents can adversely affect and increase the copper etch rate.

[0012] Therefore, there is a need in the art for a cleaning composition for back end of the line cleaning operations that effectively cleans substrates comprising porous interlayer dielectric layers, but does not significantly etch metals (e.g., Cu, Al) or the porous low-k dielectrics, and that does not significantly negativeley impact the dielectric constant of the porous low-k films.

~~BRIEF~~ SUMMARY ~~OF THE INVENTION~~

[0013] The present ~~invention~~disclosure satisfies this need by providing a composition useful for removing residue from a semiconductor substrate, the composition comprising: a) from about 15% to about 50% by weight of water; b) from about 10% to about 65% by weight of a water-miscible organic solvent; c) from about 1% to about 50% by weight of an amine compound selected from the group consisting of a at least one alkanolamine and aminopropylmorpholine; d) from about 1% to about 25% by weight of an organic acid; and e) from about 0.01% to about 8% by weight of a fluoride ion source, wherein the water-miscible organic solvent is not an ether.

[0014] In ~~another aspect~~one embodiment, the present ~~invention~~disclosure provides a method for removing residue

from a semiconductor substrate, the method comprising the steps of: contacting the semiconductor substrate with a cleaning composition of claim 1, wherein the semiconductor substrate comprises a porous dielectric material having a dielectric constant; rinsing the cleaning composition from the semiconductor substrate; and drying the semiconductor substrate, wherein the dielectric constant of the porous dielectric material does not increase more than 0.50.

[0015] In yet another ~~aspect~~embodiment, the present ~~invention~~disclosure provides a replenishment composition to be added to a cleaning composition, said replenishment composition comprises a) from about 20% to about 84% by weight of water; b) from about 15% to

about 40% by weight of a water-miscible organic solvent, wherein the water-miscible

solvent is not an ether; c) from about 1% to about 5% by weight of an amine compound

selected from the group consisting of at least one alkanolamine and at least one aminopropylmorpholine.

[0016] In yet another ~~aspect~~embodiment, the present ~~invention~~disclosure provides a method for removing unwanted residues from a semiconductor substrate comprising the steps of: contacting
the semiconductor substrate with a cleaning composition comprising: a) from about 15% to about 50% by weight of water; b) from about 10% to about 65% by weight of a water-miscible organic solvent, wherein the water-miscible solvent is not an ether; c) from about 1% to about 20% by weight of an amine compound selected from the group consisting of at least one alkanolamine and at least one aminopropylmorpholine; d) from about 1% to about 25% by weight of at least one organic acid; and e) from about 0.01% to about 8% by weight of a fluoride ion source, wherein said contacting step results in a loss of a portion of said cleaning composition; and adding a replenishment composition to said cleaning composition; said replenishment composition comprising: a) from about 20% to about 84% by weight of water; b) from about 15% to about 40% by weight of a water-miscible organic solvent, wherein the water-miscible solvent is not an ether; c) from about 1% to about 5% by weight of an amine compound selected from the group consisting of at least one alkanolamine and at least one aminopropylmorpholine.

[0017] In yet another ~~aspect~~embodiment, the present ~~invention~~disclosure provides a composition useful for removing residue from a semiconductor substrate, the composition consisting essentially
of: a) from about 15% to about 50% by weight of water; b) from about 10% to about 65% by weight of a water-miscible organic solvent selected from the group consisting of propylene glycol, glycerol, dimethylacetamide, tetrahydrofuryl alcohol, ethylene glycol, hexylene glycol, and mixtures thereof; c) from about 1% to about 50% by weight of an amine compound selected from the group consisting of a at least one alkanolamine and aminopropylmorpholine; d) from about 1% to about 25% by weight of an organic acid; e) from about 0.01% to about 8% by weight of a fluoride ion source; and f) optionally, from about 0.1% to about 15% by weight of a Cu corrosion inhibitor selected from the group consisting of benzotriazole, amino-benzotriazole, L-ascorbic acid, gallic acid, vanillin, diethylhydroxylamine, and mixtures thereof.

[0018] In still yet another ~~aspect~~embodiment, the present ~~invention~~disclosure provides a composition useful for removing residue from a semiconductor substrate, the composition consisting essentially of: a) from about 15% to about 50% by weight of water; b) from about 10% to about 65% by weight of a water-miscible organic solvent, wherein the water-miscible

solvent is not an ether; c) from about 1% to about 50% by weight of an amine compound selected from the group consisting of a at least one alkanolamine and aminopropylmorpholine; d) from about 1% to about 25% by weight of an organic acid; e) from about 0.01% to about 8% by weight of a fluoride ion source; and f) optionally, from about 0.1% to about 15% by weight of a Cu corrosion inhibitor selected from the group consisting of benzotriazole, amino-benzotriazole, L-ascorbic acid, gallic acid, vanillin, diethylhydroxylamine, and mixtures thereof,

[0018A] According to one aspect, there is provided a composition useful for removing residue from a semiconductor substrate, the composition comprising: a) from about 35% to about 50% by weight of water; b) from about 10% to about 30% by weight of a water-miscible organic solvent, wherein the water-miscible organic solvent is selected from the group consisting of propylene glycol, glycerol, dimethylacetamide, tetrahydrofuryl alcohol, ethylene glycol, hexylene glycol, and mixtures thereof; c) from about 8% to about 50% by weight of an alkanolamine selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, mono-, di- and triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol, triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, and mixtures thereof; d) from about 6% to about 10% by weight of an organic acid; and e) from about 1% to about 8% by weight of a fluoride ion source, , wherein the composition is capable of providing a copper etch rate of 3 Å/min or less.

[0018B] According to another aspect, there is provided a method for removing residue from a semiconductor substrate, the method comprising the steps of: contacting the semiconductor substrate with a cleaning composition of disclosed therein, wherein the semiconductor substrate comprises a porous dielectric material having a dielectric constant; rinsing the cleaning composition from the semiconductor substrate; and drying the semiconductor substrate, wherein the dielectric constant of the porous dielectric material does not increase more than 0.50.

[0018C] According to yet another aspect, there is provided a replenishment composition to be added to a cleaning composition, said replenishment composition comprises a) from about 20% to about 84% by weight of water; b) from about 15% to about 40% by weight of a water-miscible organic solvent, wherein the water-miscible organic solvent is selected from the group consisting of propylene glycol, glycerol, dimethylacetamide, tetrahydrofuryl alcohol, ethylene glycol, hexylene glycol, and mixtures thereof; c) from about 1% to about 5% by weight of an alkanolamine selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, mono-, di- and triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol, triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, and mixtures thereof, wherein the composition is capable of providing a copper etch rate of 3 Å/min or less.

[0018D] According to yet another aspect, there is provided a method for removing unwanted residues from a semiconductor substrate comprising the steps of: contacting the semiconductor substrate with a cleaning composition comprising: a) from about 15% to about 50% by weight of water; b) from about 10% to about 65% by weight of a water-miscible organic solvent, wherein the water-miscible organic solvent is selected from the group consisting of propylene glycol, glycerol, dimethylacetamide, tetrahydrofuryl alcohol, ethylene glycol, hexylene glycol, and mixtures thereof; c) from about 1% to about 20% by weight of an alkanolamine selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, mono-, di- and triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol, triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, and mixtures thereof; d) from about 1% to about 25% by weight of at least one organic acid; and e) from about 0.01% to about 8% by weight of a fluoride ion source, wherein said contacting step results in a loss of a portion of said cleaning composition; and adding a replenishment composition to said cleaning composition; said replenishment composition comprising: a) from about 20% to about 84% by weight of water; b) from about 15% to about 40% by weight of a water-miscible organic solvent, wherein the water-miscible organic solvent is selected from the group consisting of propylene glycol, glycerol, dimethylacetamide, tetrahydrofuryl alcohol, ethylene glycol, hexylene glycol, and mixtures thereof; c) from about 1% to about 5% by weight of an alkanolamine selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, mono-, di- and triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol, triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, and mixtures thereof.

[0018E] According to another aspect, there is provided a composition useful for removing residue from a semiconductor substrate, the composition consisting essentially of: a) from about 35% to about 50% by weight of water; b) from about 10% to about 30% by weight of a water-miscible organic solvent, wherein the water-miscible organic solvent is selected from the group consisting of propylene glycol, glycerol, dimethylacetamide, tetrahydrofuryl alcohol, ethylene glycol, hexylene glycol, and mixtures thereof; c) from about 8% to about 50% by weight of an alkanolamine selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, mono-, di- and triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol, triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, and mixtures thereof; d) from about 6% to about 10% by weight of an organic acid; e) from about 1% to about 8% by weight of a fluoride ion source; and f) optionally, from about 0.1% to about 15% by weight of a corrosion inhibitor selected from the group consisting of benzotriazole, amino-benzotriazole, L-ascorbic acid, gallic acid, vanillin, diethylhydroxylamine, and mixtures thereof, wherein the composition is capable of providing a copper etch rate of 3 Å/min or less.

BRIEF DESCRIPTION OF THE DRAWING

[0019] Figure 1 shows (a) a side wall view and (b) a top surface view including residue present on these surfaces before cleaning and (c) the side wall view and (d) the top surface view after cleaning with cleaning composition 950 described in the examples.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The present invention provides a composition whose components are present in amounts that effectively remove residue from a substrate such as, for example, a semiconductor substrate. In applications concerning semiconductor substrates, such residues include, for example, photoresist residues, ash residues, and etch residues such as, for example, residues caused by reactive ion etching. Moreover, a semiconductor substrate also includes metal, silicon, silicate and/or inter-level dielectric material such as deposited silicon oxides, which will also come into contact with the cleaning composition. Typical metals include copper, copper alloy, titanium, titanium nitride, tantalum, tantalum nitride, aluminum and/or aluminum alloy. The cleaning composition of the present invention is compatible with such materials as they exhibit a low metal and/or dielectric etch rate. In particular, compositions providing a copper etch rate of 4 Å/min or less, 3 Å/min or less, or 2 Å/min or less may be preferred.

Water

[0021] The cleaning compositions of the present invention comprise water. In the present invention, water functions in various ways such as, for example, to dissolve one or more solid components of the composition, as a carrier of the components, as an aid in the removal of the residue, as a viscosity modifier of the composition, and as a diluent, Preferably, the water employed in the cleaning composition is de-ionized (DI) water.