THE CLAIMS

What is claimed is:

1. A composition ~~for selectively removing titanium nitride and/or photoresist etch residue material from the surface of a microelectronic device having same thereon, said composition~~ comprising: at least one oxidizing agent, an etchant, at least one activator present in an amount ranging from about 0.01 percent to about 10 percent by weight, and at least one solvent, ~~.~~

~~2. The composition of claim 1,~~ wherein the at least one activator comprises a species selected from the group consisting of acetic acid, ammonium acetate, sodium acetate, potassium acetate, ~~tetramethylammonium acetate and other tetraalkylammonium acetates,~~ phosphonium acetate, ammonium butyrate, ammonium trifluoroacetate, amino acids, phosphoric acid, diammonium monohydrogen phosphate, ammonium dihydrogen phosphate, bis(tetramethylammonium) monohydrogen phosphate, disodium monohydrogen phosphate, sodium dihydrogen phosphate, dipotassium monohydrogen phosphate, potassium dihydrogen phosphate, ditetraalkylammonium monohydrogen phosphate, ditetraalkylammonium dihydrogen phosphate, diphosphonium monohydrogen phosphate, phosphonium dihydrogen phosphate, ammonium phosphonate, ~~tetraalkylammonium phosphonate,~~ sodium phosphonate, potassium phosphonate, phosphonium phosphonate, and combinations thereof, wherein when in contact with a surface of a microelectronic device, the composition selectively removes titanium nitride and/or photoresist material from the surface of the microelectronic device without removing low-k dielectric material.

~~3~~2. The composition of claim~~s~~ 1 ~~or 2~~, wherein the activator comprises ammonium acetate, diammonium monohydrogen phosphate, or combinations thereof.

~~4~~3. The composition of ~~any of~~ claim~~s~~ 1~~–3~~, wherein the oxidizing agent comprises at least one species selected from the group consisting of hydrogen peroxide (H_2O_2), $FeCl_3$, FeF_3, $Fe(NO_3)_3$, $Sr(NO_3)_2$, CoF_3, MnF_3, oxone ($2KHSO_5 \cdot KHSO_4 \cdot K_2SO_4$), periodic acid, iodic acid, vanadium (V) oxide, vanadium (IV,V) oxide, ammonium vanadate, ammonium peroxomonosulfate, ammonium chlorite (NH_4ClO_2), ammonium chlorate (NH_4ClO_3), ammonium iodate (NH_4IO_3), ammonium nitrate (NH_4NO_3), ammonium perborate (NH_4BO_3), ammonium biborate ($(NH_4)_2B_4O_7$), ammonium pentaborate ($(NH_4)B_5O_8$), ammonium

perchlorate (NH_4C1O_4), ammonium periodate (NH_4IO_4), ammonium persulfate ($(NH_4)_2S_2O_8$), ammonium hypochlorite (NH_4C1O)), ammonium tungstate ($(NH_4)_{10}H_2(W_2O_7)$), ammonium phosphate dibasic ($(NH_4)_2HPO_4$) combined with hydrogen peroxide, ammonium phosphate monobasic ($(NH_4)H_2PO_4$) combined with hydrogen peroxide, phosphoric acid combined with hydrogen peroxide, sodium persulfate ($Na_2S_2O_8$), sodium hypochlorite (NaClO), sodium perborate, potassium iodate (KIO_3), potassium permanganate ($KMnO_4$), potassium persulfate, nitric acid (HNO_3), potassium persulfate ($K_2S_2O_8$), potassium hypochlorite (KClO), tetramethylammonium chlorite ($(N(CH_3)_4)ClO_2$), tetramethylammonium chlorate ($(N(CH_3)_4)ClO_3$), tetramethylammonium iodate ($(N(CH_3)_4)IO_3$), tetramethylammonium perborate ($(N(CH_3)_4)BO_3$), tetramethylammonium perchlorate ($(N(CH_3)_4)ClO_4$), tetramethylammonium periodate ($(N(CH_3)_4)IO_4$), tetramethylammonium persulfate ($(N(CH_3)_4)S_2O_8$), tetrabutylammonium peroxomonosulfate, peroxomonosulfuric acid, ferric nitrate ($Fe(NO_3)_3$), urea hydrogen peroxide ($(CO(NH_2)_2)H_2O_2$), performic acid (H(CO)OOH), peracetic acid ($CH_3(CO)OOH$), perbutyric acid ($CH_3CH_2(CO)OOH$), perbenzoic acid, peroxytrifluoroacetic acid ($CF_3(CO)OOH$), acetic acid, formic acid, trifluoroacetic acid, benzoic acid, 1 ,4-benzoquinone, toluquinone, dimethyl- 1,4-benzoquinone, chloranil, alloxan, N-methylmorpholine N-oxide, trimethylamine N-oxide, and combinations thereof~~, preferably hydrogen peroxide~~.

~~5~~4. The composition of ~~any of~~ claim~~s~~ 1~~-~~4, wherein the at least one solvent comprises a species selected from the group consisting of water, methanol, ethanol, isopropanol, butanol, pentanol, hexanol, 2-ethyl-1-hexanol, heptanol, octanol, ethylene glycol, propylene glycol, butylene glycol, hexylene glycol, butylene carbonate, ethylene carbonate, propylene carbonate, choline bicarbonate, dipropylene glycol, dimethylsulfoxide, sulfolane, tetrahydrofurfuryl alcohol (THFA), 1 ,2-butanediol, 1 ,4-butanediol, tetramethyl urea, diethylene glycol monomethyl ether, triethylene glycol monomethyl ether, diethylene glycol monoethyl ether, triethylene glycol monoethyl ether, ethylene glycol monopropyl ether, ethylene glycol monobutyl ether, diethylene glycol monobutyl ether, triethylene glycol monobutyl ether, ethylene glycol monohexyl ether, diethylene glycol monohexyl ether, ethylene glycol phenyl ether, propylene glycol methyl ether, dipropylene glycol methyl ether (DPGME), tripropylene glycol methyl ether (TPGME),dipropylene glycol dimethyl ether, dipropylene glycol ethyl ether, propylene glycol n-propyl ether, dipropylene glycol n-propyl ether (DPGPE), tripropylene glycol n-propyl ether, propylene glycol n-butyl ether, dipropylene glycol n-butyl ether, tripropylene

glycol n- butyl ether, propylene glycol phenyl ether, 2,3-dihydrodecafluoropentane, ethyl perfluorobutylether, methyl perfluorobutylether, dimethyl sulfoxide, sulfolane, 4-methyl-2-pentanol, and combinations thereof.

~~6~~5. The composition of ~~any of~~ claim~~s~~ 1~~-4~~, wherein the at least one solvent comprises water.

~~7~~6. The composition of ~~any of~~ claim~~s~~ 1~~-4~~, wherein the at least one solvent comprises water and at least one organic solvent selected from the group consisting of methanol, ethanol, isopropanol, butanol, pentanol, hexanol, 2-ethyl-1-hexanol, heptanol, octanol, ethylene glycol, propylene glycol, butylene glycol, hexylene glycol, butylene carbonate, ethylene carbonate, propylene carbonate, choline bicarbonate, dipropylene glycol, dimethylsulfoxide, sulfolane, tetrahydrofurfuryl alcohol (THFA), 1,2-butanediol, 1,4-butanediol, tetramethyl urea, diethylene glycol monomethyl ether, triethylene glycol monomethyl ether, diethylene glycol monoethyl ether, triethylene glycol monoethyl ether, ethylene glycol monopropyl ether, ethylene glycol monobutyl ether, diethylene glycol monobutyl ether, triethylene glycol monobutyl ether, ethylene glycol monohexyl ether, diethylene glycol monohexyl ether, ethylene glycol phenyl ether, propylene glycol methyl ether, dipropylene glycol methyl ether (DPGME), tripropylene glycol methyl ether (TPGME), dipropylene glycol dimethyl ether, dipropylene glycol ethyl ether, propylene glycol n-propyl ether, dipropylene glycol n-propyl ether (DPGPE), tripropylene glycol n-propyl ether, propylene glycol n-butyl ether, dipropylene glycol n-butyl ether, tripropylene glycol n-butyl ether, propylene glycol phenyl ether, 2,3-dihydrodecafluoropentane, ethyl perfluorobutylether, methyl perfluorobutylether, dimethyl sulfoxide, sulfolane, 4-methyl-2-pentanol, and combinations thereof, preferably at least one of a glycol ether, DMSO, sulfolane, and combinations thereof.

~~8. The composition of any of claims 1-7, further comprising at least one etchant.~~

~~9~~7. The composition of claim ~~8~~1, wherein the etchant comprises a species selected from the group consisting of H_2ZrF_6, H_2TiF_6, HPF_6, HF, ammonium fluoride, tetrafluoroboric acid, hexafluorosilicic acid, tetrabutylammonium tetrafluoroborate (TBA-BF_4), ammonium hexafluorosilicate, ammonium hexafluorotitanate, tetramethylammonium hydroxide (TMAH), tetraethylammonium hydroxide (TEAH), tetrapropylammonium hydroxide (TPAH),

tetrabutylammonium hydroxide (TBAH), benzyltrimethylammonium hydroxide (BTMAH), potassium hydroxide, ammonium hydroxide, benzyltriethylammonium hydroxide (BTEAH), tetrabutylphosphonium hydroxide (TBPH), (2-hydroxyethyl) trimethylammonium hydroxide, (2-hydroxyethyl) triethylammonium hydroxide, (2-hydroxyethyl) tripropylammonium hydroxide, (1-hydroxypropyl) trimethylammonium hydroxide, ethyltrimethylammonium hydroxide, diethyldimethylammonium hydroxide (DEDMAH), 1,1,3,3-tetramethylguanidine (TMG), guanidine carbonate, arginine, ammonium hydroxide, monoethanolamine (MEA), diethanolamine (DEA), triethanolamine (TEA), ethylenediamine, cysteine, tetraalkylammonium fluoride ($NR_1R_2R_3R_4F$), where R_1, R_2, R_3, R_4 may be the same as or different from one another and is selected from the group consisting of straight-chained or branched C_1-C_6 alkyl groups, and combinations thereof.

~~10~~8. The composition of claim ~~8~~1, wherein the etchant comprises TMAH, (2-hydroxyethyl) trimethylammonium hydroxide, or combinations thereof.

~~11~~9. The composition of ~~any of the preceding~~ claim~~s~~ 1, further comprising at least one low-k passivating agent selected from the group consisting of boric acid, ammonium pentaborate, sodium tetraborate, ammonium biborate, 3-hydroxy-2-naphthoic acid, malonic acid, iminodiacetic acid, alkyltrimethlyammonium chloride, alkyltrimethlyammonium bromide, decyltrimethlyammonium chloride, carnitine, betaine and combinations thereof.

~~12~~10. The composition of ~~any of the preceding~~ claim~~s~~ 1, further comprising at least one oxidizing agent stabilizer selected from the group consisting of glycine, serine, proline, leucine, alanine, asparagine, aspartic acid, glutamine, valine, and lysine, nitrilotriacetic acid, nitrilotris(methylenephosphonic) acid, iminodiacetic acid, etidronic acid, ethylenediaminetetraacetic acid (EDTA), ethylenedinitrilotetrakis(methylenephosphonic) acid, (1,2-cyclohexylenedinitrilo)tetraacetic acid (CDTA), uric acid, tetraglyme, diethylenetriamine pentaacetic acid, diethylenetriaminepentakis(methylenephosphonic) acid, propylenediamine tetraacetic acid, ethylenediamine disuccinic acid, sulfanilamide, and combinations thereof, preferably (1,2-cyclohexylenedinitrilo)tetraacetic acid.

~~13~~11. The composition of ~~any of the preceding~~ claim~~s~~ 1, wherein the composition is substantially devoid of abrasive materials, chlorides, metal halides, and combinations thereof.

~~14~~12. The composition of ~~any of the preceding~~ claim~~s~~ 1, wherein pH of the composition is in a range from about 6 to about 10.

~~15~~13. The composition of any of claims 1-13, wherein pH of the composition is in a range from about 10 to about 13.

~~16~~14. A method of etching titanium nitride material from a surface of a microelectronic device having same thereon, said method comprising contacting the surface with a composition ~~of any of claims 1-15~~, said composition comprising at least one oxidizing agent, an etchant, at least one activator present in an amount ranging from about 0.01 percent to about 10 percent by weight, and at least one solvent, wherein the at least one activator comprises a species selected from the group consisting of acetic acid, ammonium acetate, sodium acetate, potassium acetate, tetramethylammonium acetate and other tetraalkylammonium acetates, phosphonium acetate, ammonium butyrate, ammonium trifluoroacetate, amino acids, phosphoric acid, diammonium monohydrogen phosphate, ammonium dihydrogen phosphate, bis(tetramethylammonium) monohydrogen phosphate, disodium monohydrogen phosphate, sodium dihydrogen phosphate, dipotassium monohydrogen phosphate, potassium dihydrogen phosphate, ditetraalkylammonium monohydrogen phosphate, ditetraalkylammonium dihydrogen phosphate, diphosphonium monohydrogen phosphate, phosphonium dihydrogen phosphate, ammonium phosphonate, tetraalkylammonium phosphonate, sodium phosphonate, potassium phosphonate, phosphonium phosphonate, and combinations thereof and wherein the composition selectively removes the titanium nitride and/or photoresist material from the surface of the microelectronic device without removing low-k dielectric material ~~relative to insulating materials~~.

~~17~~15. The method of claim ~~16~~14, wherein the contacting comprises time in a range from about 0.3 minute to about 30 minutes at temperature in a range of from about 20°C to about 100°C.

~~18~~16. The method of ~~any of~~ claim~~s 16 17~~ 14, wherein the composition is rinsed from the surface following the desired etching action.