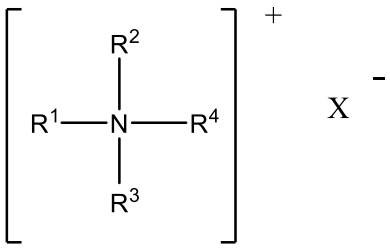
CLAIMS

1. An etching solution suitable for at least partially removing aluminum nitride from a microelectronic device during manufacture of the device, the solution comprising:

water;

a cationic surfactant having a structure represented by Formula A:



(A),

wherein, each of $R^1$, $R^2$, $R^3$, and $R^4$ is independently hydrogen, a substituted or unsubstituted $C_1 – C_{30}$ alkyl, a substituted or unsubstituted $C_3 – C_8$ cycloalkyl, a substituted or unsubstituted $C_2 – C_{30}$ alkenyl, a substituted or unsubstituted aralkyl, a substituted or unsubstituted aryl, or a substituted or unsubstituted heteroaryl, wherein not all of $R^1$, $R^2$, $R^3$, and $R^4$ are hydrogen; ~~and~~

X is an anionic counterion; and

with the proviso that $X^-$ is not a hydroxide ($-OH^-$);

a water-miscible organic solvent selected from 3-methoxy-3-methyl-1-butanol, 3-methoxy-1-butanol, and 1-methoxy-2-butanol; and

a base.

2. The etching solution of claim 1 wherein the anionic counterion is selected from a halide, a nitrate, a sulfonate, citrate, succinate, tartrate, lactate, an alkyl sulfate, an aryl sulfate, an alkoxy sulfate, an aryloxy sulfate, an alkyl sulfite, an aryl sulfite, an alkoxy sulfite, an aryloxy sulfite, acetate, triflate, a borate, and a disulfate.

3. The etching solution of claim 2 wherein the anionic counterion is the halide.

4. The etching solution of claim 3 wherein the halide is selected from fluoride, chloride, bromide, and iodide.

5. The etching solution of claim 1 wherein the anionic counterion is the sulfonate.

6. The etching solution of claim 5 wherein the sulfonate is tosylate.

7. The etching solution of any of the preceding claims wherein at least one of $R^1$, $R^2$, $R^3$, and $R^4$ is methyl.

8. The etching solution of any of claims 1-6 wherein the cationic surfactant is selected from benzyltrimethylammonium ($R^1=C_6H_5CH_2$, $R^2=R^3=R^4=CH_3$), behentrimonium ($R^1=CH_3(CH_2)_{21}$, $R^2=R^3=R^4=CH_3$), benzalkonium ($R^1=C_6H_5CH_2$, $R^2=C_nH_{2n+1(n=8, 10, 12, 14, 16, 18)}$, $R^3=R^4=CH_3$), carbethopendecinium ($R^1$=1-ethoxy-1-oxohexadecan-2-yl, $R^2=R^3=R^4=CH_3$), cetrimonium ($R^1=C_{16}H_{33}$, $R^2=R^3=R^4=CH_3$), didecyldimethylammonium ($R^1=R^2=C_{10}H_{21}$, $R^3=R^4=CH_3$), dimethyldioctadecylammonium ($R^1=R^2=C_{18}H_{37}$, $R^3=R^4=CH_3$), dimethyldipropylammonium ($R^1=R^2=C_3H_7$, $R^3=R^4=CH_3$), stearalkonium ($R^1=C_6H_5CH_2$, $R^2=C_{18}H_{37}$, $R^3=R^4=CH_3$), and tetramethylammonium ($R^1=R^2=R^3=R^4=CH_3$).

9. The etching solution of any of claims 1-7 wherein at least one of $R^1$, $R^2$, $R^3$, and $R^4$ is a substituted or unsubstituted aryl.

10. The etching solution of any of claims 1-7 or 9 wherein at least one of $R^1$, $R^2$, $R^3$, and $R^4$ is a substituted or unsubstituted aralkyl.

11. The etching solution of any of claims 1-6 wherein the cationic surfactant is an alkyl trimethylammonium tosylate.

12. The etching solution of claim 11 wherein the alkyl trimethylammonium tosylate is selected from octyl trimethylammonium tosylate, decyl trimethylammonium tosylate, dodecyl trimethylammonium tosylate, myristyl trimethylammonium tosylate, and cetyl trimethylammonium tosylate.

13. The etching solution of claim 12 wherein the alkyl trimethylammonium tosylate is cetyl trimethylammonium tosylate.

14. The etching solution of any of claims 1-6 wherein the cationic surfactant is selected from stearyltrimethylammonium chloride, cetyltrimethylammonium tosylate, octyltrimethylammonium chloride, erucyl bis-(hydroxyethyl)methylammonium chloride, erucyl trimethylammonium chloride cetyltrimethylammonium chloride, cetyltrimethylammonium bromide, myristyltrimethylammonium chloride, myristyltrimethylammonium bromide, dodecyltrimethylammonium chloride, dodecyltrimethylammonium bromide, decyltrimethylammonium chloride, decyltrimethylammonium bromide, and mixtures thereof.

~~15. The etching solution of any of the preceding claims wherein the water-miscible organic solvent is selected from ethylene glycol, propylene glycol, 1,4-butanediol, tripropylene glycol methyl ether, propylene glycol propyl ether, diethylene glycol n-butyl ether, hexyloxypropylamine, poly(oxyethylene)diamine, dimethylsulfoxide, tetrahydrofurfuryl alcohol, glycerol, alcohols, sulfoxides, and mixtures thereof.~~

~~16. The etching solution of any of the preceding claims wherein the water-miscible organic solvent is selected from 3-methoxy-3-methyl-1-butanol, 3-methoxy-1-butanol, and 1-methoxy-2-butanol.~~

~~17~~15. The etching solution of any of the preceding claims wherein the base is selected from a quarternary ammonium compound, an organic amine, an alkali metal hydroxide, and mixtures thereof.

~~18~~16. The etching solution of claim ~~17~~15 wherein the base is an alkali metal hydroxide.

~~19~~17. The etching solution of claim ~~18~~16 wherein the alkali metal hydroxide is KOH.

~~20~~18. The etching solution of any of the preceding claims comprising:
water;
cetyltrimethylammonium tosylate;
3-methoxy-3-methyl-1-butanol; and
KOH.

~~21~~19. A method for at least partially removing aluminum nitride from a microelectronic substrate during manufacture of a microelectronic device, wherein the substrate comprises aluminum nitride and silicon, the method comprising the steps of:

contacting the microelectronic substrate with an aqueous etching solution for a time sufficient to at least partially remove the aluminum nitride from the substrate, wherein the aqueous etching solution comprises the etching solution of any of claims 1-~~20~~18, and

rinsing the substrate.