CLAIMS

1. An etching solution having an etch selectivity for silicon over silicon-germanium that is greater than about 50, the etching solution comprises:

water;

a tetraalkylammonium hydroxide compound wherein not all of the alkyl groups are the same;

an amine compound;

water-miscible solvent; and

at least one of a surfactant or corrosion inhibitor.

2. The etching solution of claim 1 wherein the amine compound is an alkanolamine.

3. The etching solution of claim 2 wherein the tetraalkylammonium hydroxide compound is selected from the group consisting of benzyltrimethyl ammonium hydroxide, methyltriethylammonium hydroxide ethyltrimethyl ammonium hydroxide (ETMAH), 2-hydroxyethyltrimethyl ammonium hydroxide, benzyltriethyl ammonium hydroxide, hexadecyltrimethyl ammonium hydroxide, and mixtures thereof; and

the alkanolamine compound is selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, triethanolamine, triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol (AEE), triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, diisopropanolamine, cyclohexylaminediethanol, and mixtures thereof.

4. The etching composition of claim 1 wherein the tetraalkylammonium hydroxide compound is ethyltrimethyl ammonium hydroxide (ETMAH); and the alkanolamine is amino(ethoxy) ethanol (AEE).

5. The etching composition of claim 1 wherein the water-miscible solvent is selected from the group consisting of ethylene glycol, propylene glycol, 1,4-butanediol, tripropylene

glycol methyl ether, propylene glycol propyl ether, diethylene gycol n-butyl ether, hexyloxypropylamine, poly(oxyethylene)diamine, dimethylsulfoxide, tetrahydrofurfuryl alcohol, glycerol, alcohols, sulfoxides, or mixtures thereof.

6. The etching composition of claim 5 wherein the water-miscible solvent is glycerol.

7. The etching composition of claim 1 wherein the surfactant is present.

8. The etching composition of claim 7 wherein the surfactant is a polyalkyleneimine.

9. The etching composition of claim 1 wherein the corrosion inhibitor is present.

10. The etching composition of claim 9 wherein said corrosion inhibitor is selected from the group consisting of ethylenediaminetetraacetic acid (EDTA), butylenediaminetetraacetic acid, (1,2-cyclohexylenediamine)tetraacetic acid (CyDTA), diethylenetriaminepentaacetic acid (DETPA), ethylenediaminetetrapropionic acid, (hydroxyethyl)ethylenediaminetriacetic acid (HEDTA), N, N,N', N'-ethylenediaminetetra(methylenephosphonic) acid (EDTMP), triethylenetetraminehexaacetic acid (TTHA), 1,3-diamino-2-hydroxypropane-N,N,N',N'-tetraacetic acid (DHPTA), methyliminodiacetic acid, propylenediaminetetraacetic acid, nitrotriacetic acid (NTA), citric acid, tartaric acid, gluconic acid, saccharic acid, glyceric acid, oxalic acid, phthalic acid, maleic acid, mandelic acid, malonic acid, lactic acid, salicylic acid, propyl gallate, pyrogallol, 8-hydroxyquinoline, cysteine, and mixtures thereof.

11. A method of selectively enhancing the etch rate of silicon relative to silicon-germanium on a microelectronic device comprising silicon and silicon-germanium, the method comprising the steps of:

contacting the microelectronic device comprising silicon and silicon-germanium with an aqueous composition comprising water; at least one of a quaternary ammonium hydroxide compound and an amine compound; water-miscible solvent; at least one of a surfactant or a corrosion inhibitor; and

rinsing the microelectronic device after the silicon is at least partially removed, wherein the selectivity of the etch for silicon over silicon-germanium is greater than about 50.

12. The method of claim 11 further comprising the step of drying the semiconductor device.

13. The method of claims 11 wherein the selectivity of the etch for silicon over silicon-germanium is between about 50 and about 500.

14. The method of any of claims 11 wherein the contacting step is performed at a temperature of from about 25°C to about 100 °C.

15. The method of any of claims 11 wherein the quaternary ammonium hydroxide compound and the amine compound are present.

16. The method of any of claims 15 wherein the quaternary ammonium hydroxide compound is a tetraalkylammonium hydroxide compound wherein not all of the alkyl groups are the same; and the amine compound is an alkanolamine.

17. The method of claim 16 wherein the quaternary ammonium hydroxide compound is selected from the group consisting of benzyltrimethyl ammonium hydroxide, methyltriethylammonium hydroxide, ethyltrimethyl ammonium hydroxide (ETMAH), 2-hydroxyethyltrimethyl ammonium hydroxide, benzyltriethyl ammonium hydroxide, hexadecyltrimethyl ammonium hydroxide, and mixtures thereof; and

the alkanolamine compound is selected from the group consisting of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, triethanolamine, triisopropanolamine, 2-(2-aminoethylamino)ethanol, 2-(2-aminoethoxy)ethanol (AEE), triethanolamine, N-ethyl ethanolamine, N,N-dimethylethanolamine, N,N-diethyl ethanolamine, N-methyl diethanolamine, N-ethyl diethanolamine, cyclohexylaminediethanol, diisopropanolamine, cyclohexylaminediethanol, and mixtures thereof.

18. The method of claim 17 wherein the quaternary ammonium hydroxide compound is ethyltrimethyl ammonium hydroxide (ETMAH); and the alkanolamine is amino(ethoxy) ethanol (AEE).

19. The method of any of claims 11 wherein the water-miscible solvent is selected from the group consisting of ethylene glycol, propylene glycol, 1,4-butanediol, tripropylene glycol methyl ether, propylene glycol propyl ether, diethylene gycol n-butyl ether (e.g., commercially available under the trade designation Dowanol DB), hexyloxypropylamine, poly(oxyethylene)diamine, dimethylsulfoxide, tetrahydrofurfuryl alcohol, glycerol, alcohols, sulfoxides, or mixtures thereof.

20. The method of claim 11 wherein the corrosion inhibitor is present and selected from the group consisting of ethylenediaminetetraacetic acid (EDTA), butylenediaminetetraacetic acid, (1,2-cyclohexylenediamine)tetraacetic acid (CyDTA), diethylenetriaminepentaacetic acid (DETPA), ethylenediaminetetrapropionic acid, (hydroxyethyl)ethylenediaminetriacetic acid (HEDTA), N, N,N', N'-ethylenediaminetetra(methylenephosphonic) acid (EDTMP), triethylenetetraminehexaacetic acid (TTHA), 1,3-diamino-2-hydroxypropane-N,N,N',N'-tetraacetic acid (DHPTA), methyliminodiacetic acid, propylenediaminetetraacetic acid, nitrotriacetic acid (NTA), citric acid, tartaric acid, gluconic acid, saccharic acid, glyceric acid, oxalic acid, phthalic acid, maleic acid, mandelic acid, malonic acid, lactic acid, salicylic acid, propyl gallate, pyrogallol, 8-hydroxyquinoline, cysteine, and mixtures thereof.