CLAIMS

1. An etching solution suitable for the selective removal of silicon-germanium over silicon from a microelectronic device, which comprises:

water;

hydrogen peroxide;

a glycol ether solvent;

a fluoride ion source; and

a surfactant selected from the group consisting of a polyalkyleneimine, an acetylenic diol, a modified acetylenic diol, and mixtures thereof.

2. The etching composition of claim 1 wherein the glycol ether solvent is selected from the group consisting of butyl diglycol, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol monobutyl ether, ethylene glycol dimethyl ether, ethylene glycol diethyl ether, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol monopropyl ether, diethylene glycol monoisopropyl ether, diethylene glycol monobutyl ether, diethylene glycol monoisobutyl either, diethylene glycol monobenzyl ether, diethylene glycol dimethyl ether, diethylene glycol diethyl ether, triethylene glycol monomethyl ether, triethylene glycol dimethyl ether, polyethylene glycol monomethyl ether, diethylene glycol methyl ethyl ether, triethylene glycol ethylene glycol monomethyl ether acetate, ethylene glycol monethyl ether acetate, propylene glycol methyl ether acetate, propylene glycol monomethyl ether, propylene glycol dimethyl ether, propylene glycol monobutyl ether, propylene glycol, monopropyl ether, dipropylene glycol monomethyl ether (DPM), dipropylene glycol monopropyl ether, dipropylene glycol monoisopropyl ether, dipropylene monobutyl ether, diproplylene glycol diisopropyl ether, tripropylene glycol monomethyl ether, 1-methoxy-2-butanol, 2-methoxy-1-butanol, 2-methoxy-2-methylbutanol, 1,1-dimethoxyethane and 2-(2-butoxyethoxy) ethanol.

3. The etching composition of claim 2 wherein the glycol ether solvent is butyl diglycol.

4. The etching composition of claim 1 wherein the surfactant is polyalkyleneimine and the polyalkyleneimine is polyethyleneimine.

5. The etching composition of claim 1 wherein the fluoride ion source is selected from the group consisting of hydrofluoric acid, ammonium fluoride, ammonium bifluoride, quaternary ammonium fluorides, fluoroborates, fluoroboric acid, tetrabutylammonium tetrafluoroborate, aluminum hexafluoride, and a fluoride salt of an aliphatic primary, secondary or tertiary amine having the formula:

$$R^1NR^2R^3R^4F,$$

wherein R^1, R^2, R^3 and R^4 individually represent H or a (C_1-C_4) alkyl group.

6. The etching composition of claim 5 wherein the fluoride ion source is selected from the group consisting of ammonium fluoride, ammonium bifluoride, tetramethylammonium fluoride, tetraethylammonium fluoride, methyltriethylammonium fluoride, and tetrabutylammonium fluoride.

7. The etching composition of claim 5 wherein said fluoride ion source comprises ammonium fluoride or ammonium bifluoride.

8. The etching composition of claim 1 further comprising a buffer composition.

9. The etching composition of claim 8, wherein the buffer composition comprises an amine compound and a polyfunctional organic acid.

10. The etching composition of claim 9, wherein the amine compound comprises alkanolamine and the polyfunctional organic acid comprises polyprotic acids having at least three carboxylic acid groups.

11. The etching composition of claim 10, wherein the alkanolamine is selected from the group consisting of diethanolamine, 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.

12. The etching composition of claim 10, wherein the polyprotic acid is selected from the group consisting of citric acid, 2-methylpropane-1,2,3-triscarboxylic, benzene-1,2,3-tricarboxylic [hemimellitic], propane-1,2,3-tricarboxylic [tricarballylic], 1,cis-2,3-propenetricarboxylic acid [aconitic], e.g., butane-1,2,3,4-tetracarboxylic, cyclopentanetetra-1,2,3,4-carboxylic, benzene-1,2,4,5-tetracarboxylic [pyromellitic], benzenepentacarboxylic, and benzenehexacarboxylic [mellitic], and mixtures thereof.

13. The etching composition of claim 8, wherein the buffer composition comprises an ammonium compound and a polyfunctional organic acid.

14. A method of selectively enhancing the etch rate of silicon-germanium relative to silicon 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; hydrogen peroxide; a glycol ether solvent; a fluoride ion source; and a surfactant selected from the group consisting of a polyalkyleneimine, an acetylenic diol, a modified acetylenic diol, and mixtures thereof; and

rinsing the microelectronic device after the silicon-germanium is at least partially removed, wherein the selectivity of the etch for silicon-germanium over silicon is greater than about 10.

15. The method of claim 14 further comprising the step of drying the semiconductor device.

16. The method of claim 14 wherein the selectivity of the etch for silicon-germanium over silicon is greater than 10.

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

18. The method of claim 14 wherein the water-miscible solvent is butyl diglycol.

19. The method of claim 14 wherein the surfactant is selected from the group consisting of an acetylenic diol, a modified acetylenic diol, and mixtures thereof.

20. The method of claim 14 wherein the surfactant comprises polyalkyleneimine.

21. The method of claim 14 wherein the fluoride ion source is selected from the group consisting of hydrofluoric acid, ammonium fluoride, quaternary ammonium fluorides such as, for example, fluoroborates, fluoroboric acid, tetrabutylammonium tetrafluoroborate, aluminum hexafluoride, and a fluoride salt of an aliphatic primary, secondary or tertiary amine having the formula:

$$R^1NR^2R^3R^4F,$$

wherein R^1, R^2, R^3 and R^4 individually represent H or a (C_1-C_4) alkyl group.

22. The method of claim 21 wherein the fluoride ion source is selected from the group consisting of ammonium fluoride, ammonium bifluoride, tetramethylammonium fluoride, tetraethylammonium fluoride, methyltriethylammonium fluoride, and tetrabutylammonium fluoride.