CLAIMS

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

water;

an oxidizer comprising a quinone;

a water-miscible organic solvent;

a fluoride ion source;

a corrosion inhibitor selected from the group consisting of catechol, (C1-C6) alkylcatechol, methylcatechol, ethylcatechol, tert-butylcatechol, triazoles, benzotriazole, (C1-C10) alkylbenzotriazoles, 1,2,3-triazoles, 1,2,4-triazole, benzotriazole-5-carboxylic acid, imidazole, citric acid, tartaric acid, gluconic acid, saccharic acid, glyceric acid, oxalic acid, phthalic acid, maleic acid, mandelic acid, malonic acid, lactic acid, salicylic acid, gallic acid, gallic acid esters, methyl gallate, propyl gallate, methylbis(1-dimethylaminoethyl)amine (polycat 5), 1-octylamine, quinoline, quinoline derivatives, hydroxy-substituted quinolines, 8-hydroxyquinoline, alkyl-substituted quinolines, 2-methyl quinoline, 4-methyl quinoline, cetyltrimethyl ammonium bromide (CTAB), 11-mercaptoundecanoic acid and n-methyl-n-octylamine;

optionally a surfactant;

a buffer; and

optionally a chelating agent.

2. The etching solution of claim 1 wherein the oxidizer is selected from the group consisting of 1,4-Benzoquinone, 1,2-Benzoquinone, 1,4-Naphthoquinone, and 9,10-Anthraquinone.

3. The etching solution of claim 1 wherein the composition is substantially free of peroxides.

4. The etching composition of claim 1 wherein the water-miscible solvent is selected from the group consisting of ethylene glycol, propylene glycol, butyl diglycol, 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, dimethylacetamide, pyrrolidones, sulfur-containing solvents, or mixtures thereof.

5. The etching composition of claim 1 wherein the water-miscible solvent is selected from the group consisting of sulfoxides, sulfolane, sulfolene, sulfone or mixtures thereof.

6. The etching composition of claim 1 wherein the water-miscible solvent is selected from the group consisting of sulfolane, dimethylsulfoxide, n-methyl pyrrolidone, polyethylene glycol and dimethylacetamide or mixtures thereof.

7. The etching composition of claim 1 wherein the corrosion inhibitor is selected from the group consisting of catechol; (C1-C6) alkylcatechol, triazoles, imidazoles, gallic acid, gallic acid esters, methylbis(1-dimethylaminoethyl)amine (polycat 5), 1-octylamine, quinoline, quinoline derivatives, cetyltrimethyl ammonium bromide (CTAB), 11-mercaptoundecanoic acid, and n-methyl-n-octylamine.

8. The etching composition of claim 1 wherein the corrosion inhibitor is selected from the group consisting of methylcatechol, ethylcatechol and tert-butylcatechol, benzotriazole, (C1-C10) alkylbenzotriazoles, 1,2 3-triazoles, 1,2,4-triazole, benzotriazole-5-carboxylic acid, methyl gallate propyl gallate, hydroxy-substituted quinolines, 8-hydroxyquinoline, alkyl-substituted quinolines, 2-methyl quinoline and 4-methyl quinoline.

9. The etching composition of claim 1 wherein the corrosion inhibitor is selected from the group consisting of 8-hydroxyquinoline, cetyltrimethyl ammonium bromide (CTAB), 11-mercaptoundecanoic acid and n-methyl-n-octylamine.

10. The etching composition of claim 1 wherein the corrosion inhibitor comprises quinoline.

11. The etching composition of claim 1 wherein the buffer comprises citric acid and triammonium citrate.

12. The etching composition of claim 1, wherein the buffer composition comprises an amine compound and a polyfunctional organic acid.

13. The etching composition of claim 12, wherein the amine compound is an alkanolamine and the polyfunctional organic acid is a polyprotic acids having at least three carboxylic acid groups.

14. The etching composition of claim 13, 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.

15. The etching composition of claim 1 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.

16. The etching composition of claim 15 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.

17. The etching composition of claim 15 wherein said fluoride ion source is ammonium fluoride.

18. The etching composition of claim 1 wherein the composition comprises the chelating agent.

19. The etching composition of claim 1 wherein the composition comprises the surfactant.

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

contacting the semiconductor device comprising germanium and silicon-germanium with an aqueous composition comprising: water; an oxidizer comprising a quinone; a water-miscible organic solvent; a fluoride ion source and a corrosion inhibitor selected from the group consisting of catechol, (C1-C6) alkylcatechol, methylcatechol, ethylcatechol, tert-butylcatechol, triazoles, benzotriazole, (C1-C10) alkylbenzotriazoles, 1,2,3-triazoles, 1,2,4-triazole, benzotriazole-5-carboxylic acid, imidazole, citric acid, tartaric acid, gluconic acid, saccharic acid, glyceric acid, oxalic acid, phthalic acid, maleic acid, mandelic acid, malonic acid, lactic acid, salicylic acid, gallic acid, gallic acid esters, methyl gallate, propyl gallate, methylbis(1-dimethylaminoethyl)amine (polycat 5), 1-octylamine, quinoline, quinoline derivatives, hydroxy-substituted quinolines, 8-hydroxyquinoline, alkyl-substituted quinolines, 2-methyl quinoline, 4-methyl quinoline, cetyltrimethyl ammonium bromide (CTAB), 11-mercaptoundecanoic acid and n-methyl-n-octylamine; and optionally, a surfactant; optionally a chelating agent and a buffer; and

rinsing the composite semiconductor device after the silicon-germanium is at least partially removed, wherein the selectivity of the etch for silicon-germanium over germanium is greater than about 2.

21. The method of claim 20 further comprising the step of drying the semiconductor device.

22. The method of claim 20 wherein the selectivity of the etch for silicon-germanium over germanium is greater than 2.5.

23. The method of claim 20 wherein the contacting step is performed at a temperature of from 25 °C to 60 °C.