CLAIMS

1. An etching composition suitable for the removal of titanium nitride and molybdenum from a microelectronic device, comprising

(a) about 10 wt% to about 80 wt% water;

(b) about 0.5 wt% to about 15 wt% neat HNO_3;

(c) a base comprising one or more of

(i) about 1 wt% to about 7 wt% of one or more alkanolamine; and

(ii) about 0.7 wt% to about 2 wt% of neat NH_4OH; and

(d) a halogen ion source comprising one or more of

(i) about 1 wt% to about 30 wt% of one or more chloride ion source; and

(ii) about 0.02 wt% to about 0.15 wt% of one or more fluoride ion source.

2. The etching composition of claim 1, wherein the halogen ion source comprising one or more of:

(i) about 3 wt% to about 30 wt% NH_4Cl;

(ii) about 1 wt% to about 25 wt% of neat HCl;

(iii) about 0.02 wt% to about 0.15 wt% of neat HF; and

(iv) about 0.02 wt% to about 0.15 wt% of neat NH_4F.

3. The etching composition of claim 1, wherein the base comprises about 1 wt% to about 7 wt% of alkanolamine.

4. The etching composition of claim 1, wherein the base comprises about 0.7 wt% to about 2 wt% of neat NH_4OH.

5. The etching composition of claim 1, wherein the base is one or more alkanolamine selected from the group of N-methylethanolamine (NMEA), monoethanolamine (MEA), diethanolamine, mono-, 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.

6. The etching composition of claim 1, wherein the base comprises amino(ethoxy) ethanol.

7. The etching composition of claim 1 further comprising about 70 wt % and about 80 wt % of neat acetic acid.

8. The etching composition of claim 1 further comprising at least one heteroaromatic compound.

9. The etching composition of claim 1 further comprising at least one water-miscible solvent selected from the group of diethylene glycol butyl ether, sulfolane, and propylene carbonate.

10. The etching composition of claim 1 further comprising (i) 8-aminoquinoline and (ii) at least one

water-miscible solvent selected from the group of diethylene glycol butyl ether, sulfolane and propylene carbonate.

11. The etching composition of claim 1, wherein the composition comprises

- **(a)** about 60 wt% to about 70 wt% water;
- **(b)** about 4.8 wt% of neat HNO_3;
- **(c)** a base comprising about 1 wt % of amino(ethoxy) ethanol; and
- **(d)** a halogen ion source comprising
  - **(i)** about 27 wt% NH_4Cl;
  - **(ii)** about 2.1 wt% neat of HCl; and
  - **(iii)** about 0.025 wt% of neat HF.

12. The etching composition of claim 1, wherein the composition comprises

- **(a)** about 60 wt% to about 71 wt% water;
- **(b)** about 4.8 wt% of neat HNO_3;
- **(c)** a base comprising about 1 wt % of amino(ethoxy) ethanol; and
- **(d)** a halogen ion source comprising
  - **(i)** about 22.5 wt% NH_4Cl;
  - **(ii)** about 1.05 wt% of neat HCl; and
  - **(iii)** about 0.025 wt% of neat HF.

13. The etching composition of claim 1, wherein the composition comprises

- **(a)** about 60 wt% to about 72 wt% water;
- **(b)** about 9.6 wt% of neat HNO_3;
- **(c)** a base comprising about 2 wt % of amino(ethoxy) ethanol; and
- **(d)** a halogen ion source comprising
  - **(i)** about 16.5 wt% NH_4Cl; and
  - **(ii)** about 0.02 wt% of neat HF.

14. The etching composition of claim 1, wherein the composition comprises

- **(a)** about 60 wt% to about 70 wt% water;
- **(b)** about 9.6 wt% of neat HNO_3;
- **(c)** a base comprising about 2 wt % of amino(ethoxy) ethanol; and
- **(d)** a halogen ion source comprising
  - **(i)** about 20 wt% NH_4Cl; and
  - **(ii)** about 0.035 wt% of neat HF.

15. The etching composition of claim 1, wherein the composition comprises

(a) about 60 wt% to about 70 wt% water;

(b) about 9.6 wt% of neat HNO_3;

(c) a base comprising about 0.7 wt % of neat NH_4OH; and

(d) a halogen ion source comprising

(i) about 20 wt% NH_4Cl; and

(ii) about 0.035 wt% of neat HF.

16. The etching composition of claim 1, wherein the composition comprises

(a) about 70 wt% to about 80 wt% water;

(b) about 0.6 wt% of neat HNO_3;

(c) a base comprising about 1.45 wt % of neat NH_4OH; and

(d) a halogen ion source comprising

(i) about 21 wt% neat HCl; and

(ii) about 0.12 wt% of neat NH_4F.

17. The etching composition of claim 1, wherein the composition comprises

(a) about 10 wt% to about 15 wt% water;

(b) about 4.8 wt% of neat HNO_3;

(c) a base comprising about 7 wt % of amino(ethoxy) ethanol;

(d) a halogen ion source comprising about 0.05 wt% of neat HF; and

(e) about 75 wt % of neat acetic acid.

18. The etching composition of claim 1, wherein the composition comprises

(a) about 10 wt% to about 15 wt% water;

(b) about 4.8 wt% of neat HNO_3;

(c) a base comprising about 6 wt % of amino(ethoxy) ethanol;

(d) a halogen ion source comprising about 0.05 wt% of neat HF; and

(e) about 76 wt % of neat acetic acid.

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

(a) about 10 wt% to about 15 wt% water;

(b) about 4.8 wt% of neat HNO_3;

(c) a base comprising about 6 wt % of amino(ethoxy) ethanol;

(d) a halogen ion source comprising about 0.04 wt% of neat HF; and

(e) about 78 wt % of neat acetic acid.

20. The etching composition of claim 1, wherein the composition comprises

(a) about 10 wt% to about 15 wt% water;

(b) about 9 wt% of neat HNO_3;

(c) a base comprising about 2.03 wt % of neat NH_4OH;

(d) a halogen ion source comprising about 0.05 wt% of neat HF; and

(e) about 77 wt % of sulfolane.

21. A method of selectively enhancing the etch rate of titanium nitride and molybdenum on a composite semiconductor device comprising titanium nitride and molybdenum, the method comprising the step of:

(i) contacting the composite semiconductor device comprising titanium nitride and molybdenum with a composition of claim 1,

wherein the titanium nitride is selectively etched over the molybdenum metal at a ratio of from about 1:3 to about 15.1:1.