CLAIMS

1. A method for polishing a silicon nitride-containing substrate, the method comprising abrading a surface of a silicon nitride-containing substrate with a polishing composition comprising:

(a) 0.01 to 15% by weight of colloidal silica;

(b) 10 to 100,000 parts per million (ppm) of at least one acidic component having a pKa in the range of 1 to 4.5; and

(c) an aqueous carrier therefor;

wherein the polishing composition has a pH in the range of 0.5 pH units less than the pKa of the at least one acidic component to 1.5 pH units greater than the pKa.
1 pH unit greater than the pKa of the at least one acidic component.

2. A chemical-mechanical polishing (CMP) method for polishing a silicon nitride-containing substrate, the method comprising the steps of:

(a) contacting a surface of a silicon nitride-containing substrate with a polishing pad and an aqueous CMP composition, the CMP composition comprising 0.01 to 15% by weight of colloidal silica, 10 to 100,000 ppm of at least one acidic component having a pKa in the range of 1 to 4.5, and an aqueous carrier therefor, wherein the polishing composition has a pH in the range of 0.5 pH units less than the pKa of the at least one acidic component to 1.5 pH units greater than the pKa; and

(b) causing relative motion between the polishing pad and the substrate while maintaining a portion of the CMP composition in contact with the surface between the pad and the substrate for a time period sufficient to abrade silicon nitride from the surface.

3. The method of claim 2 wherein the substrate comprises silicon nitride and silicon oxide.

4. A chemical-mechanical polishing (CMP) method for selectively removing silicon nitride in the presence of silicon oxide in a substrate, the method comprising the steps of abrading a surface of a substrate comprising silicon nitride and silicon oxide with a polishing composition including 0.01 to 15% by weight of colloidal silica, 10 to 100,000 ppm of at least one acidic component having a pKa in the range of 1 to 4.5, and an aqueous carrier

therefor, wherein the polishing composition has a pH in the range of 0.5 pH units less than the pKa of the at least one acidic component to 1.5 pH units greater than the pKa.

5. A chemical-mechanical polishing (CMP) method for selectively removing silicon nitride in the presence of polysilicon in a substrate, the method comprising the steps of abrading a surface of a substrate comprising silicon nitride and polysilicon with a polishing composition including 0.01 to 15% by weight of colloidal silica, 10 to 100,000 ppm of at least one acidic component having a pKa in the range of 1 to 4.5, and an aqueous carrier therefor, wherein the polishing composition has a pH in the range of 0.5 pH units less than the pKa of the at least one acidic component to 1.5 pH units greater than the pKa.

6. The method of any one of claims 1, 2, 4, or 5 wherein the at least one acidic component is selected from the group consisting of an inorganic acid, a carboxylic acid, an organic phosphonic acid, an acidic heterocyclic compound, a salt thereof, and a combination of two or more of the foregoing.

7. The method of any one of claims 1, 2, 4, or 5 wherein the pH of the polishing composition is not more than 1 pH unit greater than the pKa of the at least one acidic component.

8. The method of any one of claims 1, 2, 4, or 5 wherein the pH of the polishing composition is less than 1 pH unit greater than the pKa of the at least one acidic component.

9. The method of any one of claims 1, 2, 4, or 5 wherein the colloidal silica is present in the composition in an amount in the range of 0.1 to 4% by weight.

10. The method of any one of claims 1, 2, 4, or 5 wherein the at least one acidic component is present in the polishing composition in an amount in the range of 500 to 2000 ppm.

11. A polishing composition comprising:

(a) 0.01 to 15% by weight of colloidal silica;

(b) 10 to 100,000 ppm of at least one acidic component having a pKa in the range of 1 to 4.5; and

(c) an aqueous carrier therefor;

wherein the polishing composition has a pH in the range of 0.5 pH units less than the pKa of the at least one acidic component to 1.5 pH units greater than the pKa.

12. The composition of claim 11 wherein the colloidal silica is present in the composition in an amount in the range of 0.1 to 4% by weight.

13. The composition of claim 11 wherein the at least one acidic component is present in the polishing composition in an amount in the range of 500 to 2000 ppm.

14. The composition of claim 11 wherein the at least one acidic component is selected from the group consisting of an inorganic acid, a carboxylic acid, an organic phosphonic acid, an acidic heterocyclic compound, a salt thereof, and a combination of two or more of the foregoing.

15. The composition of claim 11 wherein the pH of the polishing composition is

(a) not more than 1 pH unit greater than the pKa of the at least one acidic component; or

(b) less than 1 pH unit greater than the pKa of the at least one acidic component.

What is claimed is:

1. A chemical-mechanical polishing (CMP) method for selectively removing silicon nitride in the presence of silicon oxide in a substrate, the method comprising the steps of:

(a) abrading a surface of a substrate comprising silicon nitride and silicon oxide with a polishing composition

including about 0.01 to about 15 percent by weight of colloidal silica, about 10 to about 100,000 ppm of at least one acidic component having a pKa in the range of about 1 to about 4.5, wherein the least one acidic component is selected from the group consisting of an organic phosphonic acid, an acidic heterocyclic compound, a salt thereof, and a combination thereof, and an aqueous carrier therefor, wherein the polishing composition has a pH in the range of about 0.5 pH units less than the pKa of the at least one acidic component to about 1.5 pH units greater than the pKa; wherein a relative rate of silicon nitride removal exceeds a rate for removal of silicon oxide.

2. The method of claim 1 wherein the pH of the polishing composition is not more than about 1 pH unit greater than the pKa of the at least one acidic component.

3. The method of claim 1 wherein the pH of the polishing composition is less than about 1 pH unit greater than the pKa of the at least one acidic component.

4. The method of claim 1 wherein the colloidal silica is present in the composition in an amount in the range of about 0.1 to about 4 percent by weight.

5. The method of claim 1 wherein the at least one acidic component is present in the polishing composition in an amount in the range of about 500 to about 2000 ppm.

6. A chemical-mechanical polishing (CMP) method for selectively removing silicon nitride in the presence of polysilicon in a substrate, the method comprising the steps of:

(a) abrading a surface of a substrate comprising silicon nitride and polysilicon with a polishing composition including about 0.01 to about 15 percent by weight of colloidal silica, about 10 to about 100,000 ppm of at least one acidic component having a pKa in the range of about 1 to about 4.5, wherein the least one acidic component is selected from the group consisting of an organic phosphonic acid, an acidic heterocyclic compound, a salt thereof, and a combination thereof, and an aqueous carrier therefor, wherein the polishing composition has a pH in the range of about 0.5 pH units less than the pKa of the at least one acidic component to about 1.5 pH units greater than the pKa; wherein a relative rate of silicon nitride removal exceeds a rate for removal of polysilicon.

7. The method of claim **6** wherein the pH of the polishing composition is not more than about 1 pH unit greater than the pKa of the at least one acidic component.

8. The method of claim **6** wherein the pH of the polishing composition is less than about 1 pH unit greater than the pKa of the at least one acidic component.

9. The method of claim **6** wherein the colloidal silica is present in the composition in an amount in the range of about 0.1 to about 4 percent by weight.

10. The method of claim **6** wherein the at least one acidic component is present in the polishing composition in an amount in the range of about 500 to about 2000 ppm.