A chemical mechanical polishing (CMP) composition comprising a poly(aminoacid)

Description

This invention essentially relates to a chemical mechanical polishing (CMP) composition and its use in polishing substrates of the semiconductor industry. The CMP composition according to the invention comprises a poly(aminoacid) and shows an improved polishing performance.

In the semiconductor industry, chemical mechanical polishing (abbreviated as CMP) is a well-known technology applied in fabricating advanced photonic, microelectromechanical, and microelectronic materials and devices, such as semiconductor wafers.

During the fabrication of materials and devices used in the semiconductor industry, CMP is employed to planarize metal and/or oxide surfaces. CMP utilizes the interplay of chemical and mechanical action to achieve the planarity of the to-be-polished surfaces. Chemical action is provided by a chemical composition, also referred to as CMP composition or CMP slurry. Mechanical action is usually carried out by a polishing pad which is typically pressed onto the to-be-polished surface and mounted on a moving platen. The movement of the platen is usually linear, rotational or orbital.

In a typical CMP process step, a rotating wafer holder brings the to-be-polished wafer in contact with a polishing pad. The CMP composition is usually applied between the to-be-polished wafer and the polishing pad.

In the state of the art, CMP compositions comprising a poly(aminoacid) are known and described, for instance, in the following reference.

JP 2000-192015 A discloses a CMP polishing agent comprising cerium oxide particles, a dispersant, a biodegradable surfactant and water. One or more compounds selected from polymer dispersants, water-soluble anionic surfactants, water-soluble nonionic surfactants, water-soluble cationic surfactants and water-soluble ampholytic surfactants are used. Preferred examples of the biodegradable surfactant include – inter alia –

- polyamino acids, such as poly(aspartic acid), poly(glutamic acid), poly(lysine), aspartic acid-glutamic acid copolymer, aspartic acid-lysine copolymer and glutamic acid-lysine copolymer, and derivatives thereof, as well as
- polysaccharides such as starch, chitosan, algenic acid, carboxy methyl cellulose, methyl cellulose, pullulan, curdlan and derivatives thereof

One of the objects of the ~~present invention~~embodiments disclosed herein was to provide a CMP composition appropriate for the CMP of surfaces of dielectric substrates in shallow trench isolation and showing an improved polishing performance, particularly a high selectivity for silicon dioxide over silicon nitride or polysilicon indicated by the combination of high material removal rate (MRR) of silicon diox-

ide and low MRR of silicon nitride or polysilicon. Furthermore, a CMP composition was sought that is dipersant free, storage stable and would be ready-to-use in acidic to alkalescent pH range.

Furthermore, a respective CMP process was to be provided.

Accordingly, a CMP composition was found which comprises

(A) Colloidal or fumed inorganic particles or a mixture thereof,

(B) a poly(aminoacid) and or a salt thereof, and

(M) an aqueous medium.

In an aspect, there is provided a chemical mechanical polishing (CMP) composition comprising

(C) Colloidal or fumed inorganic particles or a mixture thereof,

(D) a poly(amino acid) and or a salt thereof,

(C) a saccharide, and

(M) an aqueous medium.

In addition, the above-mentioned objects of the ~~invention~~ embodiments disclosed herein are achieved by a process for the manufacture of a semiconductor device comprising the polishing of a substrate in the presence of said CMP composition.

In another aspect, there is provided a process for the manufacture of semiconductor devices comprising the chemical mechanical polishing of a substrate in the presence of a CMP composition as defined above.

Moreover, the use of the CMP composition of the ~~invention~~ disclosure for polishing substrates which are used in the semiconductor industry has been found, which fulfills the objects of the ~~invention~~embodiments disclosed herein.

In another aspect, there is provided the use of a CMP composition as defined above for chemical mechanical polishing of a substrate used in the semiconductor industry.

Preferred embodiments are explained in the claims and the specification. It is understood that combinations of preferred embodiments are within the scope of the present invention.

A semiconductor device can be manufactured by a process which comprises the CMP of a substrate in the presence of the CMP composition of the invention. Preferably, said process comprises the CMP of a dielectric substrate, that is a substrate having a dielectric constant of less than 6. Said process comprises more preferably the CMP of a substrate comprising silicon dioxide, most preferably the CMP of a substrate comprising silicon dioxide and silicon nitride or polysilicon, particularly the CMP of a silicon dioxide layer of a substrate which is a shallow trench isolation (STI) device or a part thereof, for example the CMP of a silicon dioxide layer of a substrate comprising silicon dioxide and silicon nitride or polysilicon.

If said process comprises the CMP of a substrate comprising silicon dioxide and silicon nitride, the selectivity of silicon dioxide to silicon nitride with regard to the material removal rate is preferably higher than 20:1, more preferably higher than 35:1, most preferably higher than 50:1, particularly higher than 70:1, for example higher than 90:1.

If said process comprises the CMP of a substrate comprising silicon dioxide and polysilicon, the selectivity of silicon dioxide to polysilicon with regard to the material removal rate is preferably higher than 50:1, more preferably higher than 80:1, most preferably higher than 100:1, particularly higher than 120:1, for example higher than 180:1.

Both the selectivity of silicon dioxide to silicon nitride as well as the selectivity of silicon dioxide to polysilicon can be adjusted by the type and concentration of poly(aminoacid) (B) and by the type of inorganic particles (A) and by setting other parameters such as pH value.

Claims

1. A chemical mechanical polishing (CMP) composition comprising
   (A) Colloidal or fumed inorganic particles or a mixture thereof,
   (B) a poly(amino acid) and or a salt thereof,
   (C) a saccharide, and
   (M) an aqueous medium,

2. The CMP composition according to claim 1, wherein the inorganic particles (A) are colloidal particles.

3. The CMP composition according to claim 1, wherein the inorganic particles (A) are fumed particles.

4. The CMP composition according to anyone of the claims 1 to 3, wherein the inorganic particles (A) are ceria particles.

5. The CMP composition according to anyone of the claims 1 to 4, wherein the mean particle size of the particles (A) is from 20 nm to 200 nm, as determined by dynamic light scattering techniques.

6. The CMP composition according to anyone of the claims 1 to 5, wherein the poly(amino acid) (B) is poly(aspartic acid), poly(glutamic acid), poly(lysine), aspartic acid-glutamic acid copolymer, aspartic acid-lysine copolymer, or glutamic acid-lysine copolymer, or a salt, or a mixture thereof.

7. The CMP composition according to anyone of the claims 1 to 6, wherein the poly(amino acid) (B) is poly(aspartic acid) and or a salt thereof.

~~8. The CMP composition according to anyone of the claims 1 to 7, further comprising (C) a saccharide.~~

~~9.~~8. The CMP composition according to anyone of the claims 1 to ~~8~~7, wherein the saccharide (C) is a mono-, di-, tri-, tetra-, penta-, hexa-, hepta-, octasaccharide, or a oxidized derivative, or a reduced derivative, or a substituted derivative or a mixture thereof.

~~10.~~9. The CMP composition according to anyone of the claims 1 to ~~9~~8, wherein the saccharide (C) is glucose, galactose, saccharose, or sucralose, or derivatives and stereoisomers, or a mixture thereof.

~~11.~~10. The CMP composition according to anyone of the claims 1 to ~~10~~9, wherein the pH value of the composition is in the range of from 4 to 9.

~~12.~~11. A process for the manufacture of semiconductor devices comprising the chemical mechanical polishing of a substrate in the presence of a CMP composition as defined in anyone of the claims 1 to ~~11~~10.

~~13.~~12. Use of a CMP composition as defined in anyone of the claims 1 to ~~11~~10 for chemical mechanical polishing of a substrate used in the semiconductor industry.

~~14.~~13. Use according to claim ~~13~~12, wherein the substrate comprises

(i) silicon dioxide, and

(ii) silicon nitride, or polysilicon.