JP 2002-025954 A discloses an alkaline composition for polishing GaAs comprising
- polyethylene glycol $-(CH_2CH_2O)_n$ ($n \geq 1$),
- or 2-methoxyethanol $CH_3O(CH_2CH_2O)H$,
- or *N,N*-diethanol methanamide $CH_3N(CH_2CH_2OH)_2$,
- or a mixture of 2-methoxyethanol and *N,N*-diethanol methanamide

as non-ionic surfactant.

US 2008/124913 A1 discloses an abrasive slurry including a non-ionic surfactant that selectively forms a passivation layer on the polysilicon layer and a method for removing an upper portion of a polysilicon layer formed over a pattern to form a polished polysilicon surface.

Objects

One of the objects of the embodiments disclosed herein was to provide a CMP composition and a CMP process appropriate for the chemical-mechanical polishing of III-V materials, particularly GaAs substrates, and showing an improved polishing performance, especially
(i) a high material removal rate (MRR) of the III-V material, for example GaAs,
(ii) a low static etch rate (SER) of the III-V material, for example GaAs,
(iii) high surface quality of the III-V material, for example GaAs, after the CMP step,
(iv) safe handling and reduction of hazardous by-products – for example the toxic gas AsH_3 in case of GaAs polishing – to a minimum, or
(v) or the combination of (i), (ii), (iii) and (iv).

Moreover, a CMP process was sought that is easy to apply and requires as few steps as possible.

Summary

In a first aspect, there is provided a process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer containing at least one III-V material in the presence of a chemical-mechanical polishing composition (CMP) composition (Q1) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP compositioninorganic,

(B) at least one amphiphilic non-ionic surfactant having
  (b1) at least one hydrophobic group; and
  (b2) at least one hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising
    (b22) oxyalkylene monomer units other than oxyethylene monomer units; and

(M) an aqueous medium.

Moreover, the use of the CMP composition (Q1) for chemical-mechanical polishing of a substrate or layer containing at least one III-V material was found.

In a second aspect, there is provided the use of the chemical-mechanical polishing composition (Q1) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition,

(B) at least one amphiphilic non-ionic surfactant having

(b1) at least one hydrophobic group; and

(b2) at least one hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising

(b22) oxyalkylene monomer units other than oxyethylene monomer units; and

(M) an aqueous medium

for chemical-mechanical polishing of a substrate or layer containing at least one III-V material.

In a third aspect, there is provided, a process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer containing at least one III-V material in the presence of a chemical mechanical polishing (CMP) composition (Q2) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition,

(C) at least one amphiphilic non-ionic polyoxyethylene surfactant having

(c1) at least one hydrophobic group which is an alkyl group having not more than 8 carbon atoms; and

(c2) at least one hydrophilic group which is a polyoxyethylene group; and

(M) an aqueous medium.

Furthermore, the use of the CMP composition (Q2) for chemical-mechanical polishing of a substrate or layer containing at least one III-V material was found.

In a fourth aspect, there is provided the use of the chemical-mechanical polishing composition (Q2) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP compositioninorganic,

(C) at least one amphiphilic non-ionic polyoxyethylene surfactant having

(c1) at least one hydrophobic group which is an alkyl group having not more than 8 carbon atoms; and

(c2) at least one hydrophilic group which is a polyoxyethylene group; and

(M) an aqueous medium

for chemical-mechanical polishing of a substrate or layer containing at least one III-V material.

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.

Claims

1. A process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer containing at least one III-V material in the presence of a chemical-mechanical polishing composition (Q1) comprising
   (A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition~~inorganic particles, organic particles, or a mixture or composite thereof~~,
   (B) at least one amphiphilic non-ionic surfactant having
      (b1) at least one hydrophobic group; and
      (b2) at least one hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising
         (b22) oxyalkylene monomer units other than oxyethylene monomer units; and
   (M) an aqueous medium.

2. A process according to claim 1, wherein the III-V material is GaN, GaP, GaAs, GaSb, AlAs, AlN, InP, InAs, InSb, InGaAs, InAlAs, AlGaAs, GaAlN, GaInN, InGaAlAs, InGaAsP, InGaP, AlInP, GaAlSb, GaInSb, GaAlAsSb, or GaInAsSb.

3. A process according to claim 1, wherein the III-V material is GaAs.

4. A process according to anyone of the claims 1 to 3, wherein the hydrophilic group (b2) is a hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising
   (b21) oxyalkylene monomer units, and
   (b22) oxyalkylene monomer units other than oxyethylene monomer units,
   said monomer units (b21) being not identical to monomer units (b22), and said polyoxyalkylene group of (b2) containing the monomer units (b21) and (b22) in random, alternating, gradient and/or block-like distribution.

5. A process according to anyone of the claims 1 to 4, wherein the hydrophilic group (b2) is a hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising
   (b21) oxyethylene monomer units, and
   (b22) oxyalkylene monomer units other than oxyethylene monomer units,
   said polyoxyalkylene group of (b2) containing the monomer units (b21) and (b22) in random, alternating, gradient and/or block-like distribution.

6. A process according to anyone of the claims 1 to 5, wherein the composition (Q1) has a pH value in the range of from 1 to 8.

7. A process according to anyone of the claims 1 to 6, wherein the composition (Q1) further comprises
(D) at least one type of an oxidizing agent.

8. A process according to anyone of the claims 1 to 7, wherein the hydrophobic group (b1) is an alkyl group having 5 to 20 carbon atoms.

9. A process according to anyone of the claims 1 to 8, wherein
the oxyalkylene monomer units other than oxyethylene monomer units (b22)
are derived from substituted oxiranes (X) wherein the substituents are selected from the group consisting of alkyl groups having 1 to 10 carbon atoms.

10. A process according to anyone of the claims 1 to 9, wherein
the oxyalkylene monomer units other than oxyethylene monomer units (b22)
are derived from methyl oxirane (propylene oxide) and/or ethyl oxirane (butylene oxide).

~~11. A process according to anyone of the claims 1 to 10, wherein the particles (A) are silica particles.~~

~~12.~~11. A process according to anyone of the claims 1 to 10~~4~~, wherein the composition (Q1) comprises
(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition,
(B) at least one amphiphilic non-ionic surfactant having
(b1) at least one hydrophobic group which is an alkyl group having 5 to 20 carbon atoms; and
(b2) at least one hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising
(b21) oxyethylene monomer units and
(b22) oxyalkylene monomer units other than oxyethylene monomer units, wherein the oxyalkylene monomer units are derived from methyl oxirane (propylene oxide) and/or ethyl oxirane (butylene oxide),
the said polyoxyalkylene group of (b2) containing the monomer units (b21) and (b22) in random, alternating, gradient and/or blocklike distribution,
(D) an oxidizing agent, and
(M) an aqueous medium.

~~13.~~12. Use of the chemical-mechanical polishing composition (Q1) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition~~inorganic particles, organic particles, or a mixture or composite thereof~~,

(B) at least one amphiphilic non-ionic surfactant having

(b1) at least one hydrophobic group; and

(b2) at least one hydrophilic group selected from the group consisting of polyoxyalkylene groups comprising

(b22) oxyalkylene monomer units other than oxyethylene monomer units; and

(M) an aqueous medium

for chemical-mechanical polishing of a substrate or layer containing at least one III-V material.

~~14.~~13. A process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer containing at least one III-V material in the presence of a chemical-mechanical polishing composition (Q2) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition~~inorganic particles, organic particles, or a mixture or composite thereof~~,

(C) at least one amphiphilic non-ionic polyoxyethylene surfactant having

(c1) at least one hydrophobic group which is an alkyl group having not more than 8 carbon atoms; and

(c2) at least one hydrophilic group which is a polyoxyethylene group; and

(M) an aqueous medium.

~~15.~~14. Use of the chemical-mechanical polishing composition (Q2) comprising

(A) Colloidal silica particles in an amount of from 0.002 wt.% to 7 wt.% based on the total weight of the respective CMP composition~~inorganic particles, organic particles, or a mixture or composite thereof~~,

(C) at least one amphiphilic non-ionic polyoxyethylene surfactant having

(c1) at least one hydrophobic group which is an alkyl group having not more than 8 carbon atoms; and

(c2) at least one hydrophilic group which is a polyoxyethylene group; and

(M) an aqueous medium

for chemical-mechanical polishing of a substrate or layer containing at least one III-V material.