Objects of the embodiments disclosed herein

One of the objects of the embodiments disclosed herein was to provide a CMP composition and a CMP process especially for the chemical-mechanical polishing of III-V materials, particularly GaAs and InP substrates which are utilized in the front-end-of-line (FEOL) IC production to form transistors, and showing an improved polishing performance, especially

(i) a high material removal rate (MRR) of the III-V material, for example GaAs and /or InP,
(ii) a high selectivity between different III-V materials (i.e. a high ratio between the material removal rates of said different III-V materials), e.g. a high selectivity of GaAs over InP,
(iii) high surface quality of the III-V material, for example GaAs and/or InP, after the CMP step,
(iv) safe handling and reduction of hazardous by-products – for example the toxic gasses $AsH_3$ and/or $PH_3$ in case of polishing GaAs and/or InP – 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

According to ~~a first aspect of~~ the present disclosure, a chemical-mechanical polishing (CMP) composition is provided comprising the following components:

(A) surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6,

(B) one or more polyethylene imines,

(C) water,

(D) optionally one or more further constituents,

wherein the pH of the composition is in the range of from 2 to 6.

In an aspect, there is provided the use of a chemical-mechanical polishing (CMP) composition for polishing a substrate or layer containing one or more III-V materials wherein the chemical-mechanical polishing composition comprises the following components:

(A) surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6

(B) one or more polyethylene imines

(C) water

(D1) hydrogen peroxide in an amount of from 0.01 to 5 wt.-% based on the total weight of the CMP composition

(D) optionally one or more further constituents,

wherein the pH of the composition is in the range of from 2 to 6 and wherein the surface modified silica particles of component (A) having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 are silica particles anionically modified with metallate ions or modified with sulfonic acid.

In ~~a further aspect~~an embodiment, the present disclosure relates to the use of a polyethylene imine as an additive for a chemical-mechanical polishing (CMP) composition, preferably as an additive for a chemical-mechanical polishing (CMP) composition comprising surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6. Preferably, the polyethylene imine has an average molecular weight in the range of from 500 g/mol to 40000 g/mol and is preferably a branched spherical polymer.

According to a further aspect of the disclosure there is provided a process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer in

Claims

1. Use of a ~~C~~chemical-mechanical polishing (CMP) composition for polishing a substrate or layer containing one or more III-V materials wherein the chemical-mechanical polishing composition comprises~~comprising~~ the following components:

(A) surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6

(B) one or more polyethylene imines

(C) water

(D1) hydrogen peroxide in an amount of from 0.01 to 5 wt.-% based on the total weight of the CMP composition

(D) optionally one or more further constituents,

wherein the pH of the composition is in the range of from 2 to 6 and wherein the surface modified silica particles of component (A) having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 are silica particles anionically modified with metallate ions or modified with sulfonic acid.

~~2. Chemical-mechanical polishing (CMP) composition according to claim 1, wherein the surface modified silica particles of component (A) having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 are silica particles anionically modified with metallate ions or modified with sulfonic acid.~~

2. Use according to claim 1 wherein the one or at least one of or all III-V materials are selected from the group consisting of GaN, GaP, GaAs, GaSb, AlAs, AlN, InP, InAs, InSb, InGaAs, InAlAs, AlGaAs, GaAlN, GaInN, InGaAlAs, InGaAsP, InGaP, AlInP, GaAlSb, GaInSb, GaAlAsSb, and GaInAsSb.

3. Use ~~Chemical-mechanical polishing (CMP) composition~~ according to claim 1 or 2, wherein the surface modified silica particles of component (A) having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 are silica particles anionically modified with metallate ions selected from the group consisting of aluminate, stannate, zincate, and plumbate.

4. Use ~~Chemical-mechanical polishing (CMP) composition~~ according to any of claims 1, 2, or 3, wherein the surface modified silica particles of component (A) having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 are silica particles anionically modified with aluminate.

5. Use ~~Chemical-mechanical polishing (CMP) composition~~ according to any preceding claim, wherein the one, at least one or all polyethylene imines have an average molecular weight in the range of from 500 g/mol to 40000 g/mol.

6. Use ~~Chemical-mechanical polishing (CMP) composition~~ according to any preceding claim, wherein

- the total amount of (A) surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 is in the range of from 0.1 to 30 wt% based on the total weight of the composition,

and/or

- the total amount of (B) polyethylene imines is in the range of from 0.01 to 3 wt%. based on the total weight of the composition.

7. Use ~~Chemical-mechanical polishing (CMP) composition~~ according to any preceding claim, wherein

- the surface modified silica particles of component (A) having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6 are silica particles anionically modified with aluminate or modified with sulfonic acid,

and/or

- the one, at least one or all polyethylene imines have an average molecular weight in the range of from 500 g/mol to 40000 g/mol.

8. Use ~~Chemical-mechanical polishing (CMP) composition~~ according to any preceding claim, wherein Chemical-mechanical polishing (CMP) composition comprising one or more further constituents as component (D),

wherein the one or at least one of or all of the further constituents of component (D) are selected from the group consisting of oxidizing agents, abrasive materials different from surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6, stabilizers, surfactants, friction reducing agents and buffer substances.

~~9. Use of a polyethylene imine as an additive for a chemical-mechanical polishing (CMP) composition, preferably as an additive for a chemical-mechanical polishing (CMP) composition comprising surface modified silica particles having a negative zeta potential of -15 mV or below at a pH in the range of from 2 to 6.~~

~~10. Use according to claim 9, wherein the polyethylene imine (B) has an average molecular weight in the range of from 500 g/mol to 40000 g/mol and is preferably a branched spherical polymer.~~

~~11~~9. Process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer in the presence of a chemical-mechanical polishing (CMP) composition as defined in any of claims 1 to 8.

~~12. Process according to claim 11, wherein the substrate or layer contains one or more III-V materials.~~

~~13~~10. Process according to ~~any of~~ claims ~~9~~11 ~~and 12~~, wherein the one or at least one of or all III-V materials are selected from the group consisting of GaN, GaP, GaAs, GaSb, AlAs, AlN, InP, InAs, InSb, InGaAs, InAlAs, AlGaAs, GaAlN, GaInN, InGaAlAs, InGaAsP, InGaP, AlInP, GaAlSb, GaInSb, GaAlAsSb, and GaInAsSb.

14. Use of a chemical-mechanical-polishing (CMP) composition as defined in any of claims 1 to 8 for polishing a substrate or layer containing one or more III-V materials wherein the one or at least one of or all III-V materials are preferably selected from the group consisting of GaN, GaP, GaAs, GaSb, AlAs, AlN, InP, InAs, InSb, InGaAs, InAlAs, AlGaAs, GaAlN, GaInN, InGaAlAs, InGaAsP, InGaP, AlInP, GaAlSb, GaInSb, GaAlAsSb, and GaInAsSb.