Objects of the disclosure

One of the objects of the present disclosure 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

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 CMP composition (Q1) comprising

(A) inorganic particles, organic particles, or a mixture or composite thereof,
(B) at least one type of a polymer comprising at least one *N*-heterocycle, and
(M) an aqueous medium

and whereas Q1 has a pH of from 1.5 to 4.5.

In a first aspect, there is provided a process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of III-V materials

in the presence of a chemical-mechanical polishing composition (Q1) comprising
(A) inorganic particles, organic particles, or a mixture or composite thereof,
(B) a polymer ~~comprising at least one *N*-heterocycle~~derived from at least one type of monomeric unit (MU) comprising at least one *N*-heterocycle wherein the *N*-heterocycle is pyrrole, pyrrolidine, imidazole, pyridine, pyrimidine, pyrazine, pyridazine, piperidine, triazole, benzotriazole, tetrazole, thiazole, isothiazole, thiazolidine, oxazole, or isooxazole, and
(M) an aqueous medium

and whereas Q1 has a pH of from 1.5 to 4.5.

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) inorganic particles, organic particles, or a mixture or composite thereof,~~
~~(B) at least one type of a polymer comprising at least one *N*-heterocycle, and~~
~~(M) an aqueous medium~~
~~and whereas Q1 has a pH of from 1.5 to 4.5~~

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

In ~~a third aspect~~an embodiment, 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 (Q2) comprising

(A) inorganic particles selected from the group consisting of alumina, ceria, copper oxide, iron oxide, nickel oxide, manganese oxide, silica, silicon nitride, silicon carbide, tin oxide, titania, titanium carbide, tungsten oxide, yttrium oxide and zirconia, or organic particles, or a mixture or composite thereof,

(C) a non-polymeric compound comprising at least one *N*-heterocycle, and

(M) an aqueous medium

and whereas Q2 has a pH of from 1.5 to 4.5.

In a second aspect, there is provided a process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer consisting of at least one III-V material

in the presence of a chemical-mechanical polishing composition (Q2) comprising

(A) silica particles,

(D) pyrrolidone,

(D) an oxidizing agent, and

(N) an aqueous medium

and whereas Q2 has a pH of from 1.5 to 4.5.

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) inorganic particles selected from the group consisting of alumina, ceria, copper oxide, iron oxide, nickel oxide, manganese oxide, silica, silicon nitride, silicon carbide, tin oxide, titania, titanium carbide, tungsten oxide, yttrium oxide and zirconia, or organic particles, or a mixture or composite thereof,~~

~~(C) a non-polymeric compound comprising at least one *N*-heterocycle, and~~

~~(M) an aqueous medium~~

~~and whereas Q2 has a pH of from 1.5 to 4.5~~

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

Claims:

1. A process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of III-V materials
in the presence of a chemical-mechanical polishing composition (Q1) comprising
(A) inorganic particles, organic particles, or a mixture or composite thereof,
(B) a polymer ~~comprising at least one *N*-heterocycle~~derived from at least one type of monomeric unit (MU) comprising at least one *N*-heterocycle wherein the *N*-heterocycle is pyrrole, pyrrolidine, imidazole, pyridine, pyrimidine, pyrazine, pyridazine, piperidine, triazole, benzotriazole, tetrazole, thiazole, isothiazole, thiazolidine, oxazole, or isooxazole, and
(M) an aqueous medium
and whereas Q1 has a pH of from 1.5 to 4.5.

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 polymer (B) is derived from at least one type of monomeric unit (MU) comprising at least one *N*-heterocycle.~~

~~5. A process according to anyone of the claims 1 to 4, wherein the *N*-heterocycle is pyrrole, pyrrolidine, pyrrolidone, imidazole, pyridine, pyrimidine, pyrazine, pyridazine, piperidine, triazole, benzotriazole, tetrazole, thiazole, isothiazole, thiazolidine, oxazole, or isooxazole.~~

~~6~~4. A process according to anyone of the claims 1 to ~~5~~3, wherein the *N*-heterocycle is ~~pyrrolidone or~~ imidazole.

~~7~~5. A process according to anyone of the claims 1 to ~~6~~4, wherein the polymer (B) is a ~~polyvinylpyrrolidone polymer, a~~ polyvinylimidazole polymer, or a vinylpyrrolidone / vinylimidazole copolymer.

~~8~~6. A process according to anyone of the claims 1 to ~~7~~5, wherein the composition (Q1) further comprises
(D) at least one type of an oxidizing agent.

~~9~~7. A process according to anyone of the claims 1 to ~~8~~6, wherein the particles (A) are silica particles.

~~10~~8. A process according to anyone of the claims 1 to ~~9~~7, wherein the III-V material is GaAs and wherein the composition (Q1) comprises

(A) silica particles,

(B) a polymer which is derived from at least one type of monomeric unit (MU) comprising ~~a pyrrolidone or~~ an imidazole,

(D) an oxidizing agent, and

(M) an aqueous medium.

~~11. Use of the chemical-mechanical polishing composition (Q1) comprising~~

~~(A) inorganic particles, organic particles, or a mixture or composite thereof,~~

~~(B) at least one type of a polymer comprising at least one *N*-heterocycle, and~~

~~(M) an aqueous medium~~

~~and whereas Q1 has a pH of from 1.5 to 4.5~~

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

~~12~~9. A process for the manufacture of semiconductor devices comprising the chemical-mechanical polishing of a substrate or layer ~~containing~~ consisting of at least one III-V material

in the presence of a chemical-mechanical polishing composition (Q2) comprising

(A) ~~inorganic particles selected from the group consisting of alumina, ceria, copper oxide, iron oxide, nickel oxide, manganese oxide, silica, silicon nitride, silicon carbide, tin oxide, titania, titanium carbide, tungsten oxide, yttrium oxide and zirconia, or organic particles, or a mixture or composite thereof~~silica particles,

(C) ~~a non-polymeric compound comprising at least one *N*-heterocycle~~pyrrolidone, ~~and~~

(D) an oxidizing agent, and

(M) an aqueous medium

and whereas Q2 has a pH of from 1.5 to 4.5.

~~13. A process according to claim 12, wherein the *N*-heterocycle does not have more than two nitrogen atoms as ring-member atoms.~~

~~14. A process according to claim 12 or 13, wherein the III-V material is GaAs and wherein the composition (Q2) comprises~~

~~(A) silica particles,~~

~~(C) pyrrolidone,~~

~~(D) an oxidizing agent, and~~

~~(M) an aqueous medium.~~

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

(A) inorganic particles selected from the group consisting of alumina, ceria, copper oxide, iron oxide, nickel oxide, manganese oxide, silica, silicon nitride, silicon carbide, tin oxide, titania, titanium carbide, tungsten oxide, yttrium oxide and zirconia, or organic particles, or a mixture or composite thereof,

(C) a non-polymeric compound comprising at least one *N*-heterocycle, and

(M) an aqueous medium

and whereas Q2 has a pH of from 1.5 to 4.5

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