

WO 2013/018015 discloses a process for the manufacture of semiconductor devices comprising the chemical mechanical polishing of elemental germanium and/or $\text{Si}_{1-x}\text{Ge}_x$ material in the presence of a chemical mechanical polishing (CMP) composition which comprises inorganic particles, organic particles, or a mixture or composite thereof. In addition to an oxidizing agent at least one type of an organic compound is comprised.

WO 2013/018016 discloses a process for the manufacture of semiconductor devices comprising the chemical mechanical polishing of elemental germanium and/or $\text{Si}_{1-x}\text{Ge}_x$ material in the presence of a chemical mechanical polishing (CMP) composition having a pH value in the range of from 3.0 to 5.5. In addition to silica particles hydrogen peroxide as oxidizing agent is comprised in the examples.

US 5 922 091 A discloses acidic aqueous polishing slurries comprising 2.5 wt% of Al_2O_3 , H_2O_2 and phosphoric acid as pH adjusting agent, wherein the pH value is adjusted with KOH as second pH adjusting agent to a pH of 2, in order to polish an Al-Si-Cu alloy, an Al-Si alloy and an Al-Cu alloy. The polishing slurry formulations are especially useful in chemical mechanical polishing of metallic thin films deposited on semiconductor substrates.

One of the objects of the embodiments disclosed herein ~~present invention~~ was to provide a use of a CMP composition. In particular a use of a CMP composition was sought showing an improved polishing performance, especially

- (i) a high material removal rate (MRR) of the substrate to be preferably polished, for example elemental germanium
- (ii) a high selectivity of germanium and/or $\text{Si}_{1-x}\text{Ge}_x$ to silicon dioxide (Ge and/or $\text{Si}_{1-x}\text{Ge}_x:\text{SiO}_2$ selectivity)
- (iii) a low static etching rate (SER) of germanium and/or $\text{Si}_{1-x}\text{Ge}_x$,
- (iv) the combination of (i), (ii), (iii).

Furthermore, a use of a CMP composition was aimed at which is a stable formulation or dispersion.

A further object of the ~~present invention~~ embodiments disclosed herein was to provide a CMP process appropriate for the chemical-mechanical polishing of substrates comprising elemental germanium or $\text{Si}_{1-x}\text{Ge}_x$ with $0.1 \leq x < 1$.

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

Accordingly, in a first aspect, there is provided a use of a chemical mechanical polishing (CMP) composition (Q) for chemical mechanical polishing of a substrate (S) comprising (i) elemental germanium or (ii) $\text{Si}_{1-x}\text{Ge}_x$ with $0.1 \leq x < 1$, wherein the CMP composition (Q) consists essentially of

(A) aluminum particles in an amount of from 0.01 to 3 wt.% based on the total weight of the CMP composition

(B) at least one oxidizer

(M) an aqueous medium and

5 (N) optionally at least one pH adjusting agent

wherein the CMP composition has a pH of from 2 to 6, ~~was found.~~

Moreover, the use of the CMP composition (Q) for polishing substrates (S) which are used in the semiconductor industry was found, which fulfills the objects of the embodiments disclosed
10 herein~~invention~~.

Further, a process for the manufacture of a semiconductor device comprising the chemical-mechanical polishing of a substrate in the presence of the CMP composition (Q) was found, which fulfills the objects of the ~~invention~~embodiments disclosed herein.

15 In a second aspect, there is provided a process for the manufacture of a semiconductor device comprising the chemical mechanical polishing of a substrate (S) used in the semiconductor industry wherein the substrate (S) comprises (i) elemental germanium or (ii) $\text{Si}_{1-x}\text{Ge}_x$ with $0.1 \leq x < 1$ in the presence of a CMP composition (Q) as defined above.

20 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.

The CMP composition (Q) used according to the invention consists essentially of the components (A), (B), (M) and optionally (N) as described below.

The CMP composition (Q) used according to the invention is additive free meaning in the context of the invention that no additives like chelating agents, corrosion inhibitors or surfactants are needed to achieve the described polishing performance.

30 Component (A) which is contained in the used CMP composition (Q) according to the invention can be one type of aluminum particles or a mixture or composite of different types of aluminum particles.

35 A composite aluminum particle is a particle comprising two or more types of aluminum particles in such a way that they are mechanically, chemically or in another way bound to each other. An example for such a composite aluminum particle is a core-shell particle comprising one type of aluminum particle in the outer sphere (shell) and another type of aluminum particle in the inner sphere (core).

40 In general various types of aluminum particles can be contained.

The chemical nature of the aluminum particles is not particularly limited. The aluminum particles may be of the same chemical nature or a mixture or composite of particles of different chemical nature. As a rule, aluminum particles of the same chemical nature are preferred.

- 5 Preferred are aluminum oxides, aluminum hydroxides, aluminum chloride or a mixture or composite thereof. More preferably alpha aluminum oxide, gamma aluminum oxide, theta aluminum