CMP composition is used to remove a portion of the substrate and to the semiconductor comprising the substrate polished thereby.

In one aspect, there is provided a process for producing cerium oxide particles, comprising the following steps: (a) contacting, under an inert atmosphere, (i) an aqueous solution of a base, (ii) an aqueous solution comprising $NO_3^-$, $Ce^{III}$, optionally $Ce^{IV}$, and (iii) an organic acid or a salt thereof to obtain a mixture, wherein the organic acid is a substituted or unsubstituted, C1-C20 -alkyl, -alkenyl or -alkynyl carboxylic acid; (b) subjecting the mixture obtained in step (a) to a thermal treatment carried out at a temperature ranging from 75°C to95°C; (c) optionally acidifying the mixture obtained in step (b); (d) optionally washing with water the solid material obtained at the end of step (b) or (c); (e) optionally subjecting the solid material obtained at the end of step (d) to a mechanical treatment to deagglomerate the particles.

In another aspect, there is provided cerium oxide particles characterized in that said particles are spheroidal in shape and exhibit a roughness index RI of at least 2, particularly of at least 3.5 wherein RI is defined by the formula:

$$RI = \frac{TEM\ size}{SSA\ size}$$

wherein "TEM size" denotes the average size of the particles measured on transmission electron microscopy images from at least 80 particles and " SSA size" denotes the theoretical average size of the particles according to the following formula:

$$SSA\ size = \frac{6}{SSA \times \rho}$$

wherein SSA denotes the BET specific surface area of the particles determined by nitrogen adsorption and ρ denotes the density of cerium(IV) oxide and is equal to7.22 g/cm$^3$ and in that said particles exhibit a carbon weight ratio ranging from 0.001 wt% to 5 wt%.

In yet another aspect, there is provided a dispersion of cerium oxide particles as described herein in a liquid medium.

In a further aspect, the present disclosure provides a use of the cerium oxide particles as described herein or of the dispersion as described herein for the preparation of a polishing composition, more particularly a CMP composition.

In another aspect, there is provided a polishing composition comprising the cerium oxide particles as described herein or the dispersion as described herein.

In yet another aspect, there is provided a method for removing a portion of a substrate, comprising polishing the substrate with a polishing composition.

## BRIEF DESCRIPTION OF THE FIGURE(S)

Figure 1 and 4 are images of the particles of the invention observed by transmission electron microscopy.

Figure 5 is an image of cerium oxide particles of the state of the art observed by transmission electron microscopy.

The pictures were obtained with a JEM-1400 (JEOL) apparatus operating at 120 kV.

## DESCRIPTION OF THE INVENTION

In the present disclosure, the expression “comprised between … and …” or the like should be understood as including the limits.

The term “cerium oxide” in connection with the particles of the invention means cerium(IV) oxide also known as ceric oxide. Cerium oxide generally has a purity degree of at least 99.8% by weight with respect to the weight of the oxide. Cerium oxide is generally crystalline ceric oxide. Some impurities, other than cerium, may be present in the oxide. The impurities may stem from the raw materials or starting materials used in the process of preparation of the cerium oxide. The total proportion of the impurities is generally lower than 0.2% by weight with respect to the cerium oxide. Residual nitrates are not considered as impurities in this application.

The expression “dispersion” in connection with dispersions of cerium oxide particles of the invention denotes a system consisting of solid fine cerium oxide particles of submicronic dimensions, stably dispersed in a liquid medium, it being possible for said particles to also optionally contain residual amounts of bound or adsorbed ions such as, for example, nitrates or ammoniums.

The invention will now be described in more details according to different embodiments thereof.

As explained earlier, one subject matter of the invention is cerium oxide particles which exhibit a roughness index (RI) of at least 5. More particularly, the roughness index of the particles of the invention may range from 5 to 20, in particular from 6 to 17, more particularly from 7 to 14.