The first aspect of the invention provides a particle comprising silicon having a particle core and an array of silicon-comprising pillars extending therefrom.

The pillars may be regular or irregular. The pillars of the present invention are 0.08 to 0.70 microns in one dimension, preferably 0.1 to 0.5 microns, more preferably 0.2 to 0.4 microns, and most preferably 0.3 microns or above. In a second dimension, the pillars are 4 to 100 microns, preferably 10 to 80 microns, more preferably 30 microns or above. The pillars thus have an aspect ratio of greater than 20:1. The pillars may have a substantially circular cross-section or a substantially non-circular cross-section.

The pillared particle may comprise undoped silicon, doped silicon or a mixture, such as a silicon-germanium mixture. In particular, the particle may have a silicon-purity of 90.00% to 99.95% by mass, preferably 90.0% to 99.5%. The silicon can be doped with any material for example, phosphorous, aluminium, silver, boron and/or zinc. The particle may be relatively low purity metallurgical grade silicon.

The particles may be regular or irregular in cross section and can be from 10 μm to 1 mm in diameter, preferably 20 μm to 150 μm, more preferably 25 μm to 75 μm.

The second aspect of the invention provides a method of fabricating a particle of the first aspect, comprising the steps of etching a particle comprising silicon. In particular, the pillars can be created by chemical reaction etching or galvanic exchange etching.

The third aspect of the invention provides a composite electrode containing particles as defined in the first aspect of the invention as one of its active

materials. In particular, the third aspect provides a composite electrode which uses copper as a current collector. In a feature of the third aspect, the electrode can be an anode.

The third aspect therefore further provides an electrochemical cell containing an electrode as defined above. In particular, there is provided an electrochemical cell in which the cathode comprises a lithium-containing compound capable of releasing and reabsorbing lithium ions as its active material. In particular, there is provided an electrochemical cell in which the cathode comprises lithium-based metal oxide or phosphate as its active material preferably $LiCoO_2$ or $LiMn_xNi_xCo_{1-2x}O_2$ or $LiFePO_4$.

The invention further provides a lithium rechargeable cell anode comprising particles of the first aspect. In particular, there is provided an anode in which the particles are part of a composite.

The third aspect further provides a cell comprising an anode and a cathode wherein the cathode preferably comprises lithium-based material, more preferably lithium cobalt dioxide.

There is further provided a device powered by a cell as defined above.

The fourth aspect of the invention provides a method of creating a composite electrode comprising the steps of preparing a solvent-based slurry containing pillared particles, coating the slurry onto a current collector and evaporating the solvent to create a composite film.

The invention further provides a method of fabricating a lithium rechargeable cell comprising the steps of creating an anode as defined above and adding a

cathode an electrolyte. In particular, the method further comprising adding a separator between cathode and the anode. A casing may be provided around the cell.

There is also provided a method of fabricating silicon-comprising fibres in which the pillars are detached from a particle of the first aspect by one or more of scraping, agitating or chemical etching.

The production of an anode electrode structure using the structured particles of the invention further overcomes the problems of reversibly reacting silicon with lithium. In particular by arranging the particles in a composite structure, that is a mixture of particles, a polymer binder and an conductive additive, or by directing bonding the structured particles to the current collector, the charge/discharge process becomes reversible and repeatable and good capacity retention is achieved. This good reversibility is considered by the present inventors to be due to the ability of the silicon pillars forming part of the structured silicon particle to absorb the volumetric expansion/contraction associated with lithium insertion/extraction from the host silicon without the pillars being broken up or destroyed. Importantly, the silicon electrodes described in this invention are fabricated by using a low purity, metallurgical grade silicon and hence produces an electrode with a potentially low cost.

Embodiments of the invention will now be described, by way of example, with reference to the figures, of which:.

Fig. 1 is a schematic diagram showing the components of a battery cell;
Fig. 2 is a electron micrograph of a pillared particle according to embodiments of the present invention;
Fig. 3 shows the overall galvanic exchange etching mechanism; and

Fig. 4 shows hypothetical kinetic curves in the form of the partial currents in the galvanic exchange etching process.

In overview the invention allows creation of pillared particles of silicon or silicon-comprising material and the use of these particles to create both a composite anode structure with a polymer binder, an conductive additive (if required) and a metal foil current collector and an electrode structure. In particular it is believed that the structure of the particles that make up the composite overcomes the problem of charge/discharge capacity loss. By providing a particle with a plurality of elongate or long thin pillars the problem of charge/discharge capacity loss is reduced.

Typically the pillars will have a length to diameter ratio of approximately 20:1. The insertion and removal of lithium into the pillars, although causing volume expansion and volume contraction, does not cause the pillars to be destroyed and hence the intra-fibre electronic conductivity is preserved.

The pillars can be made on the particles by wet etching/using a chemical galvanic exchange method for example as described in our co-pending application GB 0601318.9 with common assignees and entitled "Method of etching a silicon-based material", incorporated herewith by reference. A related method which may also be used has been disclosed in Peng K-Q, Yan, Y-J Gao, S-P, Zhu J., Adv. Materials, **14** (2004), 1164-1167 (*"Peng"*); K. Peng *et al*, Angew. Chem. Int. Ed., **44** 2737-2742; and K. Peng *et al.*, Adv. Funct. Mater., **16** (2006), 387-394; K. Peng, Z. Huang and J. Zhu, Adv. Mater., **16** (2004), 127-132; and T. Qui, L. Wu, X. Yang, G. S. Huang and Z. Y. Zhang, Appl. Phys. Lett., **84** (2004), 3867-3869. The above-mentioned methods are used to produce pillars from a high purity silicon wafer.

In a preferred embodiment of the present invention, pillars are produced on crystalline particles of relatively low purity silicon such as metallurgical grade silicon. The method comprises the five steps of: grinding and sieving; washing; nucleation; etching; and silver removal, as explained, by way of example only, later. An electron micrograph of pillared particle made in accordance with present invention is shown in Fig. 2.

Any appropriate grinding process is suitable such as power grinding or ball milling. The skilled person will appreciate that a minimum particle size will exist below which pillars cannot be etched onto the surface and instead the particle will be homogeneously etched away. Particles having a diameter less than 0.5 μm may be too small.

A more uniform pillar array, in terms of density and height, is produced by nucleating before etching. This step produces a uniform distribution of silver nuclei/islands (nuclei combine and form silver islands that are the site for pillar growth).

Silver islands delineate the formation of pillars and galvanic fluoride etching of the {100} planes: see Fig. 3. Referring to Fig. 3 there is shown a silicon surface 301 having a pillar 307. An electron 305 is transferred from a fluoride ion 303 to the silicon surface 301. The reaction of fluorine with silicon 301 and fluoride ions 303 gives rise to fluorosilicate ions 305. This is the anodic etching process. The cathode process is the discharge of silver ions 309 to produce metallic silver 311.

The structure is explained by supposing that silicon—fluoride bonds are formed as an essential step in the etch process. And furthermore that structures that are Si-F (mono-fluoride) are stable and those that are F-Si-F (di-fluoride)

In a preferred embodiment, pillars of for example 100 microns in length and 0.2 microns in diameter are fabricated on and from a silicon-comprising particle. More generally pillars of length in the range of 4 to 100 microns and diameter or transverse dimension in the range of 0.08 to 0.70 microns are fabricated from a particle having an initial size of 10 to 1000 μm.

According to the process, the silicon particles may be predominantly n- or p-type and, according to the chemical approach, and may be etched on any exposed (100), (111) or (110) crystal face. Since the etching proceeds along crystal planes, the resulting pillars are single crystals. Because of this structural feature, the pillars will be substantially straight facilitating length to diameter ratio of greater than 20:1.

The pillared-particles may then be used to form a composite electrode as described later. Alternatively, the pillars may be detached from the particle and used to form a fibre-based electrode. The detached pillars may also be described as fibres.

The invention encompasses the detachment of the pillars from the particle. The particle, with pillars attached, can be placed in a beaker or any appropriate container, covered in an inert liquid such as ethanol or water and subjected to ultra-sonic agitation. It is found that within several minutes the liquid is seen to be turbid and it can be seen by electron microscope examination that at this stage the pillars have been removed from the particle.

In an embodiment, the pillars are removed from the particle in a two stage process. In the first stage, the particles are washed several times in water and, if necessary, dried in a low vacuum system to remove the water. In the second stage, the particles are agitated in an ultrasonic bath to detach the pillars. These

juxtaposed as appropriate and the method steps performed in any appropriate order.

Although relatively high purity single crystal wafers of silicon can be etched to produce pillars of the desired parameters, the wafers themselves are very expensive owing to their high purity. Furthermore, it is difficult to arrange a pillared-wafer into an electrode-geometry. Embodiments of the present invention are advantageous because metallurgical grade silicon is relatively cheap and pillared particles may themselves be incorporated into a composite electrode without further processing. Also, pillared particles are a good source of silicon fibres and can be used themselves as the "active" ingredient in a battery electrode.

The particles used for etching may be crystalline for example mono- or poly-crystalline with a crystallite size equal to or greater than the required pillar height. The polycrystalline particle may comprise any number of crystals from example two or more.

Advantageously, metallurgical grade silicon is particularly suitable as a battery electrode because of the relatively high density of defects (compared to silicon wafers used in the semiconductor industry). This leads to a low resistance and hence high conductivity.

As the skilled person will understand, both n-type and p-type silicon can be etched and any density of charge carriers is appropriate provided the material does not become significantly degenerate.

Claims

1. A particle comprising silicon, the particle having a particle core and an array of silicon-comprising pillars extending therefrom.

2. A particle as claimed in claim 1 where in the array is regular.

3. A particle as claim in claim 1 wherein the array is irregular.

4. A particle as claimed in any preceding claim in which the pillars have a first dimensions in the range 0.08 to 0.70 microns.

5. A particle as claimed in any preceding claim in which the pillars have a second dimension in the range 4 to 100 microns.

6. A particle as claimed in any one of claims 1 to 5 in which the pillars have an aspect ratio of greater than 20:1.

7. A particle as claimed in any one of claims 1 to 6 in which the pillars have a substantially circular cross-section.

8. A particle as claimed in any of claims 1 to 7 in which the pillars have a substantially non-circular cross-section.

9. A particle as claimed in any preceding claim in which the particle and/or pillars comprise undoped silicon, doped silicon or a silicon germanium mixture.

10. A particle as claimed in any preceding claim wherein the silicon content is 90.00 to 99.95% by mass, preferably 90.0 to 99.5%.

11. A particle as claimed in any preceding claim wherein the particle is metallurgical grade silicon.

12. A particle as claimed in any preceding claim having a regular cross-section.

13. A particle as claimed in any preceding claim having an irregular cross-section.

14. A particle as claimed in any preceding claim having a first dimension of 10 μm to 1 mm, preferably 20 μm to 150 μm, more preferably 25 μm to 75 μm.

15. A particle as claimed in any preceding claim wherein the particle core is crystalline or polycrystalline.

16. A particle as claimed in any preceding claims wherein the fraction of the surface area of the particle core occupied by pillars is 0.10 to 0.50, preferably 0.20 to 0.40 and more preferable 0.25 to 0.35.

17. A method of fabricating a particle as claimed in any one of claims 1 to 16, comprising the steps of etching a particle comprising silicon.

18. A method as claimed in claim 17 in which the pillars are created by chemical reaction etching.

19. A method as claimed in claim 17 in which the pillars are created by galvanic exchange etching.

20. An electrode containing particles as defined in any of claims 1 to 16 as one of its active materials.

21. An electrode as claimed in claim 20 which uses copper as a current collector.

22. A composite electrode as claimed in claim 20 in which the electrode is an anode.

23. An electrochemical cell containing an electrode as claimed in any one of claims 20 to 22.

24. An electrochemical cell as claimed in claim 23 in which the cathode comprises a lithium-containing compound capable of releasing and reabsorbing lithium ions as its active material.

25. An electrochemical cell as claimed in claim 24 in which the cathode comprises lithium-based metal oxide, sulphide or phosphate as its active material.

26. A lithium rechargeable cell anode comprising particles as defined in any one of claims 1 to 16 as one of its active materials.

27. An anode as claimed in claim 26 in which the particles are part of a composite film.

28. A cell comprising an anode as claimed in any one of claims 26 or 27 and a cathode.

29. A cell as claimed in claim 28 in which the cathode comprises lithium-based material.

30. A cell as claimed in claim 29 in which the cathode comprises lithium cobalt dioxide.

31. A device powered by a cell as claimed in any one of claims 23 to 30.

32. A method of creating a composite electrode comprising the steps of preparing a solvent-based slurry containing particles as claimed in any of claims 1 to 16, coating the slurry onto a current collector and evaporating the solvent to create a composite film.

33. A method of fabricating a lithium rechargeable cell comprising the steps of creating an anode as claimed in either of claims 26 or 27 and adding a cathode and an electrolyte.

34. A method as claimed in claim 33 further comprising adding a separator between the cathode and the anode.

35. A method as claimed in claim 33 or claim 34 further comprising providing a casing around the cell.

36. A method of fabricating silicon-comprising fibres in which the pillars are detached from a particle as defined by any one of claims 1 to 16 by one or more of scraping, agitating or chemical etching.

The invention is defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

The first aspect of this disclosure provides a particle comprising silicon having a particle core and an array of silicon-comprising pillars extending therefrom.

The pillars may be regular or irregular. The pillars may be 0.08 to 0.70 microns in one dimension, preferably 0.1 to 0.5 microns, more preferably 0.2 to 0.4 microns, and most preferably 0.3 microns or above. In a second dimension, the pillars are 4 to 100 microns, preferably 10 to 80 microns, more preferably 30 microns or above. The pillars thus have an aspect ratio of greater than 20:1. The pillars may have a substantially circular cross-section or a substantially non-circular cross-section.

The pillared particle may comprise undoped silicon, doped silicon or a mixture, such as a silicon-germanium mixture. In particular, the particle may have a silicon-purity of 90.00% to 99.95% by mass, preferably 90.0% to 99.5%. The silicon can be doped with any material for example, phosphorous, aluminium, silver, boron and/or zinc. The particle may be relatively low purity metallurgical grade silicon.

The particles may be regular or irregular in cross section and can be from 10 µm to 1 mm in diameter, preferably 20 µm to 150 µm, more preferably 25 µm to 75 µm.

The second aspect of the disclosure provides a method of fabricating a particle of the first aspect, comprising the steps of etching a particle comprising silicon. In particular, the pillars can be created by chemical reaction etching or galvanic exchange etching.

The third aspect of the disclosure provides a composite electrode containing particles as defined in the first aspect of the disclosure as one of its active

materials. In particular, the third aspect provides a composite electrode which uses copper as a current collector. In a feature of the third aspect, the electrode can be an anode.

The third aspect therefore further provides an electrochemical cell containing an electrode as defined above. In particular, there is provided an electrochemical cell in which the cathode comprises a lithium-containing compound capable of releasing and reabsorbing lithium ions as its active material. In particular, there is provided an electrochemical cell in which the cathode comprises lithium-based metal oxide or phosphate as its active material preferably $LiCoO_2$ or $LiMn_xNi_xCo_{1-2x}O_2$ or $LiFePO_4$.

The disclosure further provides a lithium rechargeable cell anode comprising particles of the first aspect. In particular, there is provided an anode in which the particles are part of a composite.

The third aspect further provides a cell comprising an anode and a cathode wherein the cathode preferably comprises lithium-based material, more preferably lithium cobalt dioxide.

There is further provided a device powered by a cell as defined above.

The fourth aspect of the disclosure provides a method of creating a composite electrode comprising the steps of preparing a solvent-based slurry containing pillared particles, coating the slurry onto a current collector and evaporating the solvent to create a composite film.

The disclosure further provides a method of fabricating a lithium rechargeable cell comprising the steps of creating an anode as defined above and adding a

cathode an electrolyte. In particular, the method further comprising adding a separator between cathode and the anode. A casing may be provided around the cell.

There is also provided a method of fabricating silicon-comprising fibres in which the pillars are detached from a particle of the first aspect by one or more of scraping, agitating or chemical etching.

The production of an anode electrode structure using the structured particles of as disclosed herein further overcomes the problems of reversibly reacting silicon with lithium. In particular by arranging the particles in a composite structure, that is a mixture of particles, a polymer binder and an conductive additive, or by directing bonding the structured particles to the current collector, the charge/discharge process becomes reversible and repeatable and good capacity retention is achieved. This good reversibility is considered by the present inventors to be due to the ability of the silicon pillars forming part of the structured silicon particle to absorb the volumetric expansion/contraction associated with lithium insertion/extraction from the host silicon without the pillars being broken up or destroyed. Importantly, the silicon electrodes described herein are fabricated by using a low purity, metallurgical grade silicon and hence produces an electrode with a potentially low cost.

Embodiments will now be described, by way of example, with reference to the figures, of which:.

Fig. 1 is a schematic diagram showing the components of a battery cell;
Fig. 2 is a electron micrograph of a pillared particle according to embodiments of the present disclosure;
Fig. 3 shows the overall galvanic exchange etching mechanism; and

Fig. 4 shows hypothetical kinetic curves in the form of the partial currents in the galvanic exchange etching process.

In overview the techniques disclosed herein may allow creation of pillared particles of silicon or silicon-comprising material and the use of these particles to create both a composite anode structure with a polymer binder, an conductive additive (if required) and a metal foil current collector and an electrode structure. In particular it is believed that the structure of the particles that make up the composite overcomes the problem of charge/discharge capacity loss. By providing a particle with a plurality of elongate or long thin pillars the problem of charge/discharge capacity loss is reduced.

Typically the pillars will have a length to diameter ratio of approximately 20:1. The insertion and removal of lithium into the pillars, although causing volume expansion and volume contraction, does not cause the pillars to be destroyed and hence the intra-fibre electronic conductivity is preserved.

The pillars can be made on the particles by wet etching/using a chemical galvanic exchange method for example as described in our co-pending application GB 0601318.9 with common assignees and entitled "Method of etching a silicon-based material", incorporated herewith by reference. A related method which may also be used has been disclosed in Peng K-Q, Yan, Y-J Gao, S-P, Zhu J., Adv. Materials, **14** (2004), 1164-1167 (*"Peng"*); K. Peng *et al*, Angew. Chem. Int. Ed., **44** 2737-2742; and K. Peng *et al*., Adv. Funct. Mater., **16** (2006), 387-394; K. Peng, Z. Huang and J. Zhu, Adv. Mater., **16** (2004), 127-132; and T. Qui, L. Wu, X. Yang, G. S. Huang and Z. Y. Zhang, Appl. Phys. Lett., **84** (2004), 3867-3869. The above-mentioned methods are used to produce pillars from a high purity silicon wafer.

In a preferred embodiment, pillars are produced on crystalline particles of relatively low purity silicon such as metallurgical grade silicon. The method comprises the five steps of: grinding and sieving; washing; nucleation; etching; and silver removal, as explained, by way of example only, later. An electron micrograph of pillared particle made in accordance with the techniques disclosed herein is shown in Fig. 2.

Any appropriate grinding process is suitable such as power grinding or ball milling. The skilled person will appreciate that a minimum particle size will exist below which pillars cannot be etched onto the surface and instead the particle will be homogeneously etched away. Particles having a diameter less than 0.5 μm may be too small.

A more uniform pillar array, in terms of density and height, is produced by nucleating before etching. This step produces a uniform distribution of silver nuclei/islands (nuclei combine and form silver islands that are the site for pillar growth).

Silver islands delineate the formation of pillars and galvanic fluoride etching of the {100} planes: see Fig. 3. Referring to Fig. 3 there is shown a silicon surface 301 having a pillar 307. An electron 305 is transferred from a fluoride ion 303 to the silicon surface 301. The reaction of fluorine with silicon 301 and fluoride ions 303 gives rise to fluorosilicate ions 305. This is the anodic etching process. The cathode process is the discharge of silver ions 309 to produce metallic silver 311.

The structure is explained by supposing that silicon—fluoride bonds are formed as an essential step in the etch process. And furthermore that structures that are Si-F (mono-fluoride) are stable and those that are F-Si-F (di-fluoride)

In a preferred embodiment, pillars of for example 100 microns in length and 0.2 microns in diameter are fabricated on and from a silicon-comprising particle. More generally pillars of length in the range of 4 to 100 microns and diameter or transverse dimension in the range of 0.08 to 0.70 microns are fabricated from a particle having an initial size of 10 to 1000 μm.

According to the process, the silicon particles may be predominantly n- or p-type and, according to the chemical approach, and may be etched on any exposed (100), (111) or (110) crystal face. Since the etching proceeds along crystal planes, the resulting pillars are single crystals. Because of this structural feature, the pillars will be substantially straight facilitating length to diameter ratio of greater than 20:1.

The pillared-particles may then be used to form a composite electrode as described later. Alternatively, the pillars may be detached from the particle and used to form a fibre-based electrode. The detached pillars may also be described as fibres.

The disclosure encompasses the detachment of the pillars from the particle. The particle, with pillars attached, can be placed in a beaker or any appropriate container, covered in an inert liquid such as ethanol or water and subjected to ultra-sonic agitation. It is found that within several minutes the liquid is seen to be turbid and it can be seen by electron microscope examination that at this stage the pillars have been removed from the particle.

In an embodiment, the pillars are removed from the particle in a two stage process. In the first stage, the particles are washed several times in water and, if necessary, dried in a low vacuum system to remove the water. In the second stage, the particles are agitated in an ultrasonic bath to detach the pillars. These

juxtaposed as appropriate and the method steps performed in any appropriate order.

Although relatively high purity single crystal wafers of silicon can be etched to produce pillars of the desired parameters, the wafers themselves are very expensive owing to their high purity. Furthermore, it is difficult to arrange a pillared-wafer into an electrode-geometry. Embodiments of the present disclosure are advantageous because metallurgical grade silicon is relatively cheap and pillared particles may themselves be incorporated into a composite electrode without further processing. Also, pillared particles are a good source of silicon fibres and can be used themselves as the "active" ingredient in a battery electrode.

The particles used for etching may be crystalline for example mono- or poly-crystalline with a crystallite size equal to or greater than the required pillar height. The polycrystalline particle may comprise any number of crystals from example two or more.

Advantageously, metallurgical grade silicon is particularly suitable as a battery electrode because of the relatively high density of defects (compared to silicon wafers used in the semiconductor industry). This leads to a low resistance and hence high conductivity.

As the skilled person will understand, both n-type and p-type silicon can be etched and any density of charge carriers is appropriate provided the material does not become significantly degenerate**.**

CLAIMS

1. A structured particle comprising silicon for an active material of an electrode, the particle having a core having a particle shape and a plurality of silicon-comprising elongate structures extending outwards therefrom.

2. The structured particle as claimed in claim 1 wherein the plurality of silicon-comprising elongate structures are a regular or irregular array of silicon-comprising pillars.

3. The structured particle as claimed in claim 1 wherein
the core comprises silicon and has {100}, {111} or {110} crystal surfaces.

4. The structured particle as claimed in any one of claims 1 to 3 wherein the elongate structures comprise silicon-comprising pillars having sides with {110} surfaces.

5. The structured particle as claimed in any one of claims 1 to 3 wherein the elongate structures extend from a plurality of surfaces of the particle core.

6. The structured particle as claimed in any one of claims 1 to 3 wherein the elongate structures extend all over the surface of the particle core.

7. The structured particle as claimed in any one of claims 1 to 3 wherein the fraction of the surface area of the particle core occupied by the elongate structures is 0.10 to 0.50.

8. The structured particle as claimed in any one of claims 1 to 3 in which the elongate structures have a length to diameter ratio of greater than 20:1.

9. The structured particle as claimed in any one of claims 1 to 3 in which the elongate structures have a first dimension in the range 0.08 to 0.70 microns.

10. The structured particle as claimed in any one of claims 1 to 3 in which the elongate structures have a substantially circular cross-section.

11. The structured particle as claimed in any one of claims 1 to 3 in which the elongate structures have a substantially non-circular cross-section.

12. The structured particle as claimed in any one of claims 1 to 3 in which the particle comprises undoped silicon, doped silicon or a silicon germanium mixture.

13. The structured particle as claimed in claim 12 in which the particle comprises doped silicon, wherein the silicon is doped with at least one of phosphorous, aluminum, silver, boron and zinc.

14. The structured particle as claimed in any one of claims 1 to 3 wherein the silicon has a silicon purity of 90.00 to 99.95% by mass.

15. The structured particle as claimed in any one of claims 1 to 3, the particle having a diameter of at least 0.5 μm.

16. The structured particle as claimed in claim 15, the particle having a diameter of 10 μm to 1 mm.

17. An electrode comprising the structured particle as claimed in any one of claims 1 to 3.

18. The electrode as claimed in claim 17 in which the electrode comprises a porous composite comprising a plurality of the structured particles.

19. The electrode as claimed in claim 17 in which the structured particles are directly bonded to a current collector.

20. The electrode as claimed in claim 18 in which the structured particles comprise 70 to 95% by mass of the porous composite.

21. The electrode as claimed in claim 18 wherein the porous composite further comprises at least one of a binder and conductive additive.

22. The electrode as claimed in claims 17 in which the electrode is an electrode for an electrochemical cell and the plurality of structured particles are one of its active materials.

23. The electrode as claimed in claim 22 in which the elongate structures of the structured particles comprise silicon-comprising pillars having sides with {110} surfaces.

24. An electrochemical cell containing an electrode as claimed in claim 22.

25. The electrochemical cell as claimed in claim 24 further comprising a cathode comprising a lithium-containing compound capable of releasing and reabsorbing lithium ions as its active material.

26. A device powered by an electrochemical cell as claimed in claim 24.

27. A method of fabricating an electrode, the method comprising depositing a layer comprising a plurality of structured particles as claimed in any one of claims 1 to 3.

28. A method of creating a composite electrode comprising the steps of preparing a solvent-based slurry containing a plurality of structured particles as claimed in any of claims 1 to 3, coating the slurry onto a current collector and evaporating the solvent to create a porous composite film.

29. A method of fabricating a lithium-ion rechargeable cell comprising the steps of creating an electrode as claimed in claim 27 and adding a cathode and an electrolyte.

30. A method of fabricating a silicon-comprising structured particle as claimed in any one of claims 1 to 3, the method comprising the step of wet etching a silicon-comprising particle.

31. The method as claimed in claim 30, in which the step of wet etching comprises chemical reaction etching, galvanic exchange etching or galvanic fluoride etching.

32. The method as claimed in claim 30, further comprising a nucleation step before etching in which a distribution of silver nuclei are formed on the silicon-comprising particle.

33. The method as claimed in claim 31, in which the step of wet etching comprises galvanic exchange etching comprising an anodic etching process represented by $Si + 6F^- = SiF_6^{2-} + 4e^-$ and the removal of electrons is accompanied by the discharge of silver ions.

34. The method as claimed in claim 31, comprising the step of depositing a metal from a compound containing Cu or Pt having an electric potential higher than hydrogen onto the silicon-comprising particle.

35. The method as claimed in claim 32, further comprising the step of removing the silver left on the etched structured particles using a solution comprising nitric acid.

36. A method of fabricating silicon-comprising fibres in which elongate structures are detached from the silicon-comprising structured particle as defined by any one of claims 1 to 3 to form the said silicon-comprising fibres.

37. The method as claimed in claim 36 wherein the fibres are detached from the silicon-comprising structured particle by one or more of scraping, agitating or chemical etching.

38. The method as claimed in claim 37 wherein the fibres have sides with {110} surfaces.

39. A method of fabricating an electrode, the method comprising depositing a coating comprising the silicon-comprising fibres fabricated by the method of claim 36.

40. A method of creating a porous composite electrode comprising the steps of preparing a solvent-based slurry comprising the silicon-comprising fibres, fabricated by the method of claim 36, and coating the slurry onto a current collector and evaporating the solvent to create a composite film.

41. An electrode containing a plurality of silicon-comprising fibres fabricated by the method of claim 36, as one of its active materials.

42. An electrochemical cell comprising an electrode as claimed in claim 41.

43. The electrochemical cell as claimed in claim 42 further comprising a cathode comprising a lithium-containing compound capable of releasing and reabsorbing lithium ions as its active material.

44. A device powered by an electrochemical cell as claimed in claim 43.

45. An electrode for an electrochemical cell comprising a plurality of silicon-comprising particles as one of its active materials wherein the silicon-comprising particles comprise at least one of:

(a) a structured particle comprising a core having a particle shape and a plurality of silicon-comprising elongate structures extending therefrom; or

(b) silicon-comprising fibres;

wherein the elongate structures or fibres have sides with surfaces terminating on {110} planes.

46. The structured particle as claimed in claim 1, wherein the core has a faceted shape in which a direction perpendicular to the surface of the core is discontinuously changed.