CLAIMS

1. A method of making porous silicon, comprising:

(a) etching silicon in an electrochemical cell under current, to produce porous silicon having pores from 10 nm to 10 μm in diameter with an pore depth of 5-100 μm; and

(b) coating said porous silicon with at least 1 nm of a passivating material, wherein the passivating material is carbon or gold and wherein said coated porous silicon has a charge capacity of at least 1000 mAh/g for at least 50 cycles.

2. The method of claim 1, wherein said etching uses a high density plasma gas or an acid, wherein the acid comprises hydrofluoric acid (HF) in dimethylformamide (DMF).

3. The method of claim 1, wherein said silicon is crystalline silicon, semicrystalline silicon, amorphous silicon, doped silicon, coated silicon, silicon precoated with silicon nanoparticles, or combinations thereof.

4. The method of claim 1, wherein said coating is 20 nm of gold.

5. The method of claim 2, wherein the porosity of said coated porous silicon can be increased by decreasing the concentration of acid and/or increasing the current.

6. The method of claim 1, wherein the coated porous silicon has a pore depth of 5-10 μm and a charge capacity of at least 2000 mAh/g for at least 60 cycles.

7. The method of claim 1, wherein the coated porous silicon has a pore width of 2 μm and a lifespan of at least at least 200 cycles.

8. The method of claim 3, wherein the silicon is coated with silicon nanoparticles, and the coated porous silicon has an pore width of about less than 1 μm, a depth of 5- 10 μm and a lifespan of at least at least 150 cycles.

9. The method of claim 2, wherein the current ranges from 1-20 raA, the HF:DMF ratio ranges from 1 :5 to 1 :35 and the current is applied for 30-300 minutes.

10. The method of claim 2, wherein the current is 8 mA, the HF:DMF:water ratio is 1 :10: 1, the current is applied for 240 minutes, and the pore depth is at least 6 microns and pore diameter is at least 2 microns.

11. The method of claim 2, wherein the current is 8 mA, the HF: DMF ratio is 2:25, and the current is applied in intervals of about 30 minutes for 120 minutes, and the pore depth is at least 5 microns.

12. The method of claim 1, comprising:

(a) etching crystalline silicon in HF:DMF in a ratio of 1 :5-1 :35 in an electrochemical cell at 3-10 mA, under constant or intermittent current for 30-300 minutes, to produce porous silicon having pores from 10 nm to 10 μm in diameter with a pore depth of 5- 100 μm; and

(b) coating said porous silicon with 5-50 nm gold, wherein said coated porous silicon has a charge capacity of at least 3000 mAh/g for at least 60 cycles.

13. An anode comprising the coated porous silicon of claim 1.

14. An anode comprising the coated porous silicon of claim 12.

15. An anode comprising

the coated porous silicon of claim 1, that is crushed, bound with a matrix material and shaped to form an anode; or is used as is or is lifted off bulk silicon and used on a optional substrate with an optional transition layer that is optionally doped.

16. A rechargeable battery comprising an anode containing the coated porous silicon of claim 1.

17. A rechargeable battery comprising an anode containing the coated porous silicon of claim 12.

18. A rechargeable battery comprising an anode comprising the coated porous silicon of claim 1 overlayed on top of an optional substrate, an optional transition layer between said coated porous silicon and said substrate, a separator and a cathode material.

19. The rechargeable battery of claim 18, wherein said substrate is selected from the group consisting of copper, bulk silicon, carbon, silicon carbide, carbon, graphite, carbon fibers, graphene sheets, fullerenes, carbon nanotubes, and graphene platelets and combinations thereof.

20. A rechargeable battery comprising anode comprising the porous silicon of claim 1 , a separator and a cathode material, wherein said battery can be packaged in a coil-cell, pouch cell, cylindrical cell, or a prismatic cell configuration.

CLAIMS

1. A method which is a method for making coated porous silicon and in which

(a) the silicon in an electrochemical cell is etched under a current in order to produce porous silicon with pores having depths in the range of 5–100 μm and diameters in the range of 10 nm-10 μm;

(b) said porous silicon is coated with an immobilizing material of at least 1 nm;

said immobilizing material is carbon or gold, and

said coated porous silicon has a charging capacity of at least 1000 mAh/g for at least 50 cycles.

2. A method in accordance with Claim 1, in which

said etching uses a high-density plasma gas or an acid, and

said acid contains hydrofluoric acid (HF) in dimethyl formamide (DMF).

3. A method in accordance with Claim 1, in which said silicon is crystalline silicon, semi-crystalline silicon, non-crystalline silicon, doped silicon, coated silicon, a silicon which was coated beforehand with silicon nanoparticles, or a combination of these.

4. A method in accordance with Claim 1, in which said coating is 20 nm of gold.

5. A method in accordance with Claim 2, in which the porosity of said coated porous silicon can be increased by reducing the concentration of said acid and/or increasing said current.

6. A method in accordance with Claim 1, in which said coated porous silicon has pores with depths in the range of 5–10 μm and a charging capacity of at least 2000 mAh/g for at least 60 cycles.

7. A method in accordance with Claim 1, in which said coated porous silicon has a pore width of 2 μm and a lifetime of at least 200 cycles.

8. A method in accordance with Claim 3, in which said silicon is coated with silicon nanoparticles, said coated porous silicon has pore widths of less than approximately 1 μm and pore depths in the range of 5–10 μm, and it has a lifetime of at least 150 cycles.

9. A method in accordance with Claim 2, in which said current is in the range of 1–20 mA, the HF:DMF ratio is in the range of 1:5 to 1:35, and said current is applied for 30–300 minutes.

10. A method in accordance with Claim 2, in which said current is in the range of 8 mA, the ratios of HF:DMF:water are 1:10:1, said current is applied for 240 minutes, the depths of said pores are at least 6 microns, and the pore diameters are at least 2 microns.

11. A method in accordance with Claim 2, in which said current is 8 mA, the HF:DMF ratio is 2:25, said current is applied for 120 minutes with an interval of approximately 30 minutes, and the depths of said pores are at least 5 microns.

12. A method in accordance with Claim 1, in which said coated porous silicon has a charging capacity of at least 3000 mAh/g for at least 60 cycles, and it includes

(a) the silicon in an electrochemical cell is etched under a constant current or an intermittent current of 3–10 mA for 30–300 minutes, with an HF:DMF ratio in the range of 1:5–

1:35, in order to form a porous silicon with pores having depths of 5–100 µm and diameters of 10 nm–10 µm, and

(b) said porous silicon is coated with 5–50 nm of gold.

13. An anode which is provided with said coated porous silicon in accordance with Claim 1.

14. An anode which is provided with said coated porous silicon in accordance with Claim 12.

15. An anode which is provided with said coated porous silicon in accordance with Claim 1;

said coated porous silicon is compressed and bonded with a matrix material and molded to form an anode, or it is used as is, or it is lifted off from bulk silicon and used on any desired substrate which has any desired transitional layers which are arbitrarily doped.

16. A rechargable battery which is provided with an anode which contains said coated porous silicon in accordance with Claim 1.

17. A rechargable battery which is provided with an anode which contains said coated porous silicon in accordance with Claim 12.

18. A rechargable battery which is provided with an anode which is provided with said coated porous silicon in accordance with Claim 1, and which has an upper part of any arbitrary base, arbitrary transitional layers between said coated porous silicon and said base, a separator, and is put on top of a cathode material.

19. A rechargable battery in accordance with Claim 18, in which said base is selected from a group consisting of copper, bulk silicon, carbon, silicon carbide, carbon, graphite, carbon fibers, a graphene sheet, fullerene, carbon nanotubes, graphene platelets, and combinations of these.

20. A rechargable battery which is provided with an anode, a separator, and a cathode material, and said anode has said porous silicon in accordance with Claim 1, and said battery can be packaged in a coil battery, pouch battery, tubular battery, or prismatically shaped battery structure.