CLAIMS

1. A particulate material consisting of a plurality of composite particles, wherein the composite particles comprise:

(a) a porous particle framework comprising micropores and mesopores, wherein the total volume of micropores and mesopores in the porous particle framework as measured by gas adsorption is from 0.5 to 1.8 cm^3/g; and

(b) a plurality of nanoscale elemental silicon domains located within the pores of the porous particle framework,

wherein:

(i) the composite particles comprise from 30 to 70 wt% silicon;

(ii) at least 30 wt% of the silicon is surface silicon as determined by thermogravimetric analysis (TGA), wherein the TGA is carried out in air with a temperature ramp rate of 10 °C/min, wherein the surface silicon percentage is determined according to the following formula:

$$Y = 1.875 \times [(M_{max} - M_{min}) / M_f] \times 100\%$$

wherein Y is the percentage of surface silicon as a proportion of the total silicon in the sample, M_{max} is the maximum mass of the sample measured in the temperature range between 550 °C to 650 °C, M_{min} is the minimum mass of the sample above 150 °C and below 500 °C, and M_f is the mass of the sample at completion of oxidation at 1400 °C;

(iii) the hydrogen content of the composite particles is no more than 1.2 wt%;

(iv) the weight ratio of oxygen to silicon in the composite particles is no more than 0.15; and

(v) the BET surface area of the composite particles is no more than 40 m^2/g.

2. A particulate material according to claim 1, wherein at least 32 wt% of the silicon, or at least 35 wt% of the silicon, or at least 38 wt% of the silicon, or at least 40 wt% of the silicon, or at least 42 wt% of the silicon, or at least 45 wt% of the silicon, or at least 48 wt% of the silicon, or at least 50 wt% of the silicon is surface silicon as determined by thermogravimetric analysis (TGA).

3. A particulate material according to claim 1 or claim 2, wherein no more than 6 wt% of the silicon, or no more than 5 wt%, or no more than 4 wt% of the silicon, or no more than 3.5 wt%, or no more than 3 wt%, or no more than 2.5 wt%, or no more than 2 wt% or no more than 1.5 wt% of the silicon is coarse bulk silicon as determined by thermogravimetric analysis (TGA), wherein the TGA is carried out in air with a temperature ramp rate of 10 °C/min, wherein the coarse bulk silicon percentage is determined according to the following formula:

$$Z = 1.875 \times [(M_f - M_{800}) / M_f] \times 100\%$$

wherein Z is the percentage of coarse bulk silicon, M_{800} is the mass of the sample at 800 °C, and M_f is the mass of ash at completion of oxidation at 1400 °C.

4. A particulate material according to any preceding claim, wherein the total volume of micropores and mesopores in the porous particle framework as measured by gas adsorption is in the range from 0.55 to 1.6 cm^3/g, or from 0.6 to 1.4 cm^3/g, or from 0.65 to 1.3 cm^3/g, or from 0.7 to 1.2 cm^3/g, or from 0.75 to 1.1 cm^3/g.

5. A particulate material according to any preceding claim, wherein the PD_{90} pore diameter of the porous particle framework is no more than 12 nm, or no more than 10 nm, or no more than 8 nm, or no more than 6 nm, or no more than 4 nm, wherein the PD_{90} pore diameter is the volume-based 90th percentile pore diameter of the porous particle framework, based on the total volume of micropores and mesopores.

6. A particulate material according to any preceding claim, wherein the PD_{50} pore diameter of the porous particle framework is in the range from 1 to 2 nm, or from 1 to 1.9 nm, or from 1.1 to 1.8 nm, or from 1.1 to 1.7 nm, or from 1.2 to 1.6 nm, wherein the PD_{50} pore diameter is the volume-based 50th percentile pore diameter of the porous particle framework, based on the total volume of micropores and mesopores.

97. A particulate material according to any preceding claim, wherein the micropore volume fraction of the porous particle framework is in the range from 0.45 to 0.95, or in the range from 0.5 to 0.9, or from 0.5 to 0.85, or from 0.55 to 0.80, or from 0.55 to 0.75, or from 0.6 to 0.7, based on the total volume of micropores and mesopores.

8. A particulate material according to any preceding claim, wherein the total volume of pores having a diameter in the range of from greater than 50 nm to 100 nm is no more than $0.2\times P^1$, or no more than $0.1\times P^1$, or no more than $0.05\times P^1$, or no more than $0.02\times P^1$, or no more than $0.01\times P^1$, or no more than $0.005\times P^1$, wherein P^1 represents the total volume of micropores and mesopores in the porous particle framework.

9. A particulate material according to any preceding claim, wherein the porous particle framework has a BET surface area from 1200 to 3000 m^2/g.

10. A particulate material according to any preceding claim, wherein the porous particle framework is a conductive porous particle framework, preferably a conductive porous carbon particle framework, more preferably a conductive porous carbon particle framework comprising at least 80 wt% carbon, or at least 85 wt% carbon, or at least 90 wt% carbon, or at least 95 wt% carbon.

11. A particulate material according to any preceding claim, wherein the porous particle framework is a hard carbon particle framework.

12. A particulate material according to any preceding claim, wherein the composite particles comprise from 32 to 68 wt% silicon, or from 35 to 66 wt% silicon, or from 38 to 64 wt% silicon, or from 40 to 62 wt% silicon, or from 42 to 60 wt% silicon, or from 44 to 58 wt% silicon.

13. A particulate material according to any preceding claim, wherein the weight ratio of silicon to the porous particle framework is in the range from [$0.50 \times P^1$ to $1.90 \times P^1$], wherein P^1 represents the total volume of micropores and mesopores in the porous particle framework.

14. A particulate material according to any preceding claim, wherein the composite particles comprise at least 0.1 wt% hydrogen, or at least 0.15 wt% hydrogen, or at least 0.2 wt% hydrogen.

15. A particulate material according to any preceding claim, wherein the composite particles comprise no more than 1.1 wt% hydrogen, or no more than 1 wt% hydrogen, or no more than 0.95 wt% hydrogen, or no more than 0.9 wt% hydrogen, or no more than 0.85 wt% hydrogen, or no more than 0.8 wt% hydrogen, or no more than 0.75 wt% hydrogen.

16. A particulate material according to any preceding claim, wherein the composite particles comprise no more than 6 wt% oxygen, or no more than 5.5 wt% oxygen, or no more than 5 wt% oxygen, or no more than 4.5 wt% oxygen, or no more than 4 wt% oxygen, or no more than 3 wt% oxygen, or no more than 2 wt% oxygen, or no more than 1 wt% oxygen, or no more than 0.5 wt% oxygen.

17. A particulate material according to any preceding claim, wherein the weight ratio of oxygen to silicon in the composite particles is no more than 0.14, or no more than 0.12, or no more than 0.1, or no more than 0.09, or no more than 0.08.

18. A particulate material according to any preceding claim, wherein the weight ratio of hydrogen to silicon in the composite particles is in the range from 1.0 to 3.0 wt%, or in the range from 1.4 to 2.8 wt%.

19. A particulate material according to any preceding claim, wherein silicon and carbon together constitute at least 90 wt% of the composite particles, or at least 95 wt% of the composite particles.

20. A particulate material according to any preceding claim, wherein the composite particles have a D_{50} particle diameter in the range from 1 to 20 µm, or from 1 to 18 µm, or from 1 to 16 µm, or from 2 to 16 µm, or from 2 to 14 µm, or from 2 to 12 µm, or from 2 to 10 µm, or from 2 to 8 µm.

21. A particulate material according to any preceding claim, wherein the composite particles have a D_1 particle size of at least 0.5 µm, or at least 0.8 µm, or at least 1.0 µm, or at least 1.2 µm, or at least 1.4 µm, or at least 1.5 µm.

22. A particulate material according to any preceding claim, wherein the composite particles have a D_{90} particle diameter of no more than 30 µm, or no more than 25 µm, or no more than 20 µm, or no more than 15 µm.

23. A particulate material according to any preceding claim, wherein the composite particles have a BET surface area in the range from 1 m^2/g to 25 m^2/g, more preferably in the range from 2 to 15 m^2/g.

24. A particulate material according to any preceding claim, wherein the total volume of micropores and mesopores in the composite particles is no more than 0.15 x P^1, or

up to 0.10 x P^1, or up to 0.05 x P^1, or up to 0.02 x P^1, wherein P^1 represents the total volume of micropores and mesopores in the porous particle framework.

25. A particulate material according to any preceding claim, wherein the total volume of micropores and mesopores in the composite particles is no more than 0.1 cm^3/g, or no more than 0.09 cm^3/g, or no more than 0.08 cm^3/g, or no more than 0.07 cm^3/g, or no more than 0.06 cm^3/g, or no more than 0.05 cm^3/g.

26. A particulate material according to any preceding claim, wherein the composite particles are obtained by chemical vapor infiltration (CVI) of a silicon-containing precursor into the pore structure of a porous carbon framework.

27. A particulate material according to any preceding claim, wherein the composite particles comprise a lithium-ion permeable coating, wherein the lithium-ion permeable coating is selected from a conductive carbon coating and a lithium-ion permeable solid electrolyte.

28. A particulate material according to any preceding claim, wherein the composite particles comprise a silicon surface that has been treated with a passivating agent.

29. A particulate material according to any preceding claim, wherein the composite particles have a tap density of more than 0.7 g/cm^3, or at least 0.8 g/cm^3, or at least 0.85 g/cm^3, or at least 0.9 g/cm^3.

30. A particulate material according to any preceding claim, wherein

the total volume of micropores and mesopores in the porous particle framework as measured by gas adsorption is from 0.6 to 1.4 cm^3/g;

the micropore volume fraction based on the total volume of micropores and mesopores in the porous particle framework is from 0.5 to 0.9;

the silicon content of the composite particles is from 40 to 70 wt%;

at least 30 wt% of the silicon is surface silicon as determined by thermogravimetric analysis (TGA);

no more than 5 wt% of the silicon is coarse bulk silicon as determined by thermogravimetric analysis (TGA); and

the hydrogen content of the composite particles is from 0.4 to 0.9 wt%.

31. A composition comprising the particulate material of any of claims 1 to 30 and at least one other component.

32. An electrode comprising the particulate material of any of claims 1 to 30 or the composition of claim 31.

33. A rechargeable metal-ion battery comprising the electrode of claim 32.