CLAIMS

1. A process for use in producing pure nano-Silicon, nano-Silicon-carbon composites or nano-Silicon-carbon coated composites, comprising:

a) using one or more DC transferred arc for melting and vaporizing silicon; and

b) quenching the silicon vapour to form at least one of nano particles and nano wires.

2. The process of Claim 1, wherein a reactor is provided, the reactor including the arc, an electrode and a crucible, and wherein the reactor is typically under vacuum.

~~3. The process of Claim 2, wherein the reactor is under vacuum.~~

~~4~~3. The process of ~~any one of~~ Claim~~s~~ 2 ~~to 3~~, wherein gas is injected in the reactor for quenching the silicon vapour, and wherein the gas is typically injected by a vortex, and wherein the electrode is typically hollow such that the gas is injected via the electrode.

~~5. The process of Claim 4, wherein the gas is injected by a vortex.~~

~~6. The process of Claim 4, wherein the electrode is hollow and the gas is injected via the electrode.~~

~~7~~4. The process of any one of Claims 1 to ~~6~~3, wherein the electrode is consumable and movable to control an arc voltage and to compensate for electrode erosion.

~~8~~5. The process of any one of Claims 1 to ~~7~~4, wherein a quenching gas used for quenching the silicon vapour includes an inert gas, such as argon.

~~9~~6. The process of any one of Claims 1 to ~~7~~4, wherein a quenching mixture used for quenching the silicon vapour includes an inert gas and carbon containing precursors such as hydrocarbons, so as to introduce hydrocarbons in a vaporization zone.

~~10~~7. The process of any one of Claims 1 to ~~4~~3, wherein quenching of the silicon vapour is effected one of (1) internally of the reactor via at least one of a vortex and a hollow electrode and (2) externally of the reactor, for instance using one of a De Laval nozzle (C-D nozzle), a cold gas or liquid stream, and a solid-state quenching.

~~11. The process of any one of Claims 1 to 4, wherein quenching of the silicon vapour is effected externally of the reactor, for instance using one of a De Laval nozzle (C-D nozzle), a cold gas or liquid stream, and a solid-state quenching.~~

~~12. The process of any one of Claims 1 to 11, wherein quenched particles are filtered, for instance with candle filter(s), then collected in a sealed collector and the collected powder is thereafter transferred, for instance, to a glove box having a controlled inert atmosphere to avoid oxidation.~~

~~13. The process of any one of Claims 1 to 12, wherein raw Silicon is provided in a batch or via a continuous feed.~~

~~14~~8. The process of any one of Claims 2 to ~~13~~7, wherein raw Silicon is first melted by one of (1) an arc between the electrode and a bottom of a crucible of the reactor, a melted silicon acting as an anode and then being vaporized by an arc formed between the electrode and the anode, and (2) an induction coil, a

melted silicon acting as an anode and then being vaporized by an arc formed between the electrode and the anode, wherein the induction coil is typically adapted to indirectly preheat and melt the raw Silicon by induction heating of a crucible, with the vaporization of the melted silicon typically being achieved primarily by the arc.

~~15. The process of any one of Claims 2 to 13, wherein raw Silicon is first melted by an induction coil, a melted silicon acting as an anode and then being vaporized by an arc formed between the electrode and the anode.~~

~~16. The process of Claim 15, wherein the induction coil is provided in walls of the reactor.~~

~~17. The process of Claim 15, wherein the induction coil is adapted to directly preheat and melt the raw Silicon, with the vaporization of the melted silicon being achieved primarily by the arc.~~

~~18. The process of Claim 15, wherein the induction coil is adapted to indirectly preheat and melt the raw Silicon by induction heating of a crucible, with the vaporization of the melted silicon being achieved primarily by the arc.~~

~~19. The process of any one of Claims 5 and 10, wherein a quenching rate is adapted to be adjusted by a number and diameter of holes defined in the vortex and the gas flow rate, and also for instance by selecting a quenching gas-entering angle.~~

~~20~~9. A process for manufacturing lithium-ion batteries using nano-Silicon-carbon composites or nano-Silicon-carbon coated composites produced by the process of any one of Claims 1 to ~~19~~8.

~~21~~10. An apparatus for use in producing pure nano-Silicon, nano-Silicon-carbon composites or nano-Silicon-carbon coated composites, comprising:

a) a reactor including at least one electrode and adapted to provide at least one arc, e.g. a DC transferred arc, for melting and vaporizing silicon provided in the reactor, the reactor typically including a crucible, and the reactor being typically under vacuum, for instance via a vacuum pump; and

b) a quenching system for quenching a so-produced silicon vapour so as to form at least one of nano particles and nano wires, the quenching system being typically adapted to adjust a flow rate of a quenching gas.

~~22. The apparatus of Claim 21, wherein the reactor includes a crucible.~~

~~23. The apparatus of any one of Claims 21 to 22, wherein the reactor is under vacuum, for instance via a vacuum pump.~~

~~24~~11. The apparatus of ~~any one of~~ Claim~~s 21~~ 10~~to 23~~, wherein a gas injector is provided for injecting ~~a~~ the quenching gas in the reactor for quenching the silicon vapour, wherein the quenching gas is for instance injected by a vortex, and wherein the electrode is typically hollow and the gas injector typically includes the hollow electrode for injecting the quenching gas in a chamber of the reactor via the hollow electrode.

~~25. The apparatus of Claim 24, wherein the quenching gas is injected by a vortex.~~

~~26. The apparatus of Claim 24, wherein the electrode is hollow and the gas injector includes the hollow electrode for injecting the quenching gas in a chamber of the reactor via the hollow electrode.~~

~~27. The apparatus of any one of Claims 21 to 26, wherein the electrode is consumable and movable, typically vertically, to control an arc voltage and to compensate for electrode erosion.~~

~~28. The apparatus of any one of Claims 24 to 27, wherein the quenching gas used for quenching the silicon vapour includes an inert gas, such as argon.~~

~~29. The apparatus of any one of Claims 21 to 27, wherein a quenching mixture used for quenching the silicon vapour includes an inert gas and carbon containing precursors such as hydrocarbons, so as to introduce hydrocarbons in a vaporization zone of the reactor.~~

~~30~~12. The apparatus of any one of Claims ~~21~~ 10 to ~~24~~11, wherein the quenching system is provided one of (1) internally of the reactor and includes at least one of a vortex and a hollow electrode for quenching of the silicon vapour, and (2) externally of the reactor and includes, for instance, one of a De Laval nozzle (C-D nozzle), a cold gas or liquid stream, and a solid-state quenching.

~~31. The apparatus of any one of Claims 21 to 24, wherein the quenching system is provided externally of the reactor and includes, for instance, one of a De Laval nozzle (C-D nozzle), a cold gas or liquid stream, and a solid-state quenching.~~

~~32~~13. The apparatus of any one of Claims ~~21~~ 10 to ~~31~~12, wherein a filtration system is provided externally of the reactor and is adapted to filter quenched particles, the filtration system including, for instance, candle filter(s).

~~33~~14. The apparatus of any one of Claims ~~21~~ 10 to ~~32~~13, wherein a collector is provided externally of the reactor and is adapted to collect filtered particles, and wherein a glove box is typically provided downstream of the collector and is

typically adapted to contain the powder received from the collector, the glove box typically having a controlled inert atmosphere to avoid oxidation of the powder.

~~34. The apparatus of Claim 33, wherein a glove box is provided downstream of the collector and is adapted to contain the powder received from the collector, the glove box having a controlled inert atmosphere to avoid oxidation of the powder.~~

~~35~~15. The apparatus of any one of Claims 10~~1~~ to ~~34~~14, wherein the reactor includes a feed entry for feeding, typically in a continuous manner, raw Silicon to a reactor chamber.

~~36~~16. The apparatus of any one of Claims ~~21~~ 10 to ~~35~~15, wherein the reactor includes a crucible, and an initial arc is adapted to be provided between the electrode and a bottom of the crucible for melting raw Silicon provided in the reactor, a so melted silicon being then adapted to act as an anode and to be vaporized by the arc formed between the electrode and the anode.

~~37~~17. The apparatus of any one of Claims ~~21~~ 10 to ~~35~~15, wherein the reactor includes an induction coil adapted to melt raw Silicon provided in the reactor, a so melted silicon being then adapted to act as an anode and to be vaporized by the arc formed between the electrode and the anode, and wherein the induction coil is for instance provided in walls of the reactor.

~~38. The apparatus of Claim 37, wherein the induction coil is provided in walls of the reactor.~~

~~39~~18. The apparatus of any one of Claims 10 to 16, wherein the reactor includes an induction coil adapted to melt raw Silicon provided in the reactor, a so melted silicon being then adapted to act as an anode and to be vaporized by the arc

formed between the electrode and the anode~~Claim 37~~, wherein the induction coil is adapted to directly preheat and melt the raw Silicon, with a vaporization of the so melted silicon being achieved primarily by the arc.

~~40~~19. The apparatus of any one of Claims 10 to 16, wherein the reactor includes an induction coil adapted to melt raw Silicon provided in the reactor, a so melted silicon being then adapted to act as an anode and to be vaporized by the arc formed between the electrode and the anode~~Claim 37~~, wherein the induction coil is adapted to indirectly preheat and melt the raw Silicon by induction heating of a crucible of the reactor, with a vaporization of the so melted silicon being achieved primarily by the arc.

~~41~~20. The apparatus of any one of Claims ~~25~~ 11 and ~~30~~12, wherein holes are defined in the vortex, a number and diameter of the holes being selected for adjusting a quenching rate, and wherein the quenching system is for instance adapted to provide a selected quenching gas-entering angle.

~~42. The apparatus of Claim 41, wherein the quenching system is adapted to provide a selected quenching gas-entering angle.~~

~~43. The apparatus of any one of Claims 21 to 42, wherein the quenching system is adapted to adjust a flow rate of the quenching gas.~~

~~44~~21. The apparatus of any one of Claims ~~21~~ 10 to ~~43~~20, wherein an extension projects externally from a crucible of the reactor to connect the crucible to a power supply.

~~45~~22. The apparatus of any one of Claims ~~21~~ 10 to ~~44~~21, wherein the electrode is provided above a bottom of the reactor, raw silicon being adapted to be provided on the bottom of the reactor, the quenching system being adapted to

supply the quenching gas between the raw silicon and a lower end of the electrode, wherein the arc is provided between the electrode acting as a cathode and a melted raw Silicon acting as an anode.

4623. The apparatus of any one of Claims 21 10 to 4522, wherein an inlet is provided at an upper end of the reactor for feeding raw Silicon thereto, and wherein an outlet is provided at an upper end of the reactor for withdrawing quenched particles from the reactor, and wherein the outlet communicates downstream thereof with a filtration unit adapted to filter the quenched particles.

47. The apparatus of Claim 46, wherein the outlet communicates downstream thereof with a filtration unit adapted to filter the quenched particles.

4824. An apparatus for manufacturing lithium-ion batteries using nano-Silicon-carbon composites or nano-Silicon-carbon coated composites produced by the apparatus of any one of Claims 21 10 to 4723.