

That Which is Claimed is:

1. A battery comprising:
a cathode; and
an anode comprised of an anode active material and lithiated with a lithium source;
wherein the anode active material is alloyed or intercalated with lithium particles diffused from the lithium source to form a three-dimensional porous framework within the anode that provides reduced electrode deterioration due to volume expansion.
2. The battery of Claim 1, wherein the anode active materials have a porosity between about 25% and about 60%.
3. The battery of Claim 2, wherein the porosity of the anode active material is increased between about 1% and about 10% when alloyed or intercalated with lithium particles diffused from the lithium source to form the three-dimensional porous framework within the anode.
4. The battery of Claim 1 further including a lithiation control layer on a surface of the anode adapted to control an activation rate and a pre-lithiation rate of the anode.
5. The battery of Claim 4, wherein the lithiation control layer is a film on the surface of the anode formed from the polymer binder and is adapted to slow diffusion of lithium onto the surface.
6. The battery of Claim 1, wherein a surface of the anode is porous and the bulk of the electrode has a gradient porosity to increase lithium conductivity and mitigate lithium plating and enable fast charging of the battery.
7. The battery of Claim 6, wherein the surface of the anode has a porosity greater than about 40%.
8. The battery of Claim 6, wherein the gradient porosity has an increased surface area for lower charge transfer impedance and increased charge rate capabilities.

9. The battery of Claim 1, wherein the anode has a first cycle efficiency greater than about 90%.

10. The battery of Claim 1, wherein the lithium source is stabilized lithium metal powder.

11. The battery of Claim 1, wherein the lithium source comprises a printable lithium formulation comprised of a lithium metal powder, a polymer binder compatible with the lithium metal powder, a rheology modifier compatible with the lithium metal powder, and a solvent compatible with the lithium metal powder and with the polymer binder.

12. The battery of Claim 11, wherein the rheology modifier is selected from the group consisting of carbonaceous materials, silicon-containing materials, tin-containing materials, Group IIA oxides, Group IIIA oxides, Group IVB oxides, Group VB oxides and Group VIA oxides.

13. The battery of Claim 12, wherein the carbonaceous material is selected from the group consisting of carbon black, carbon nanotubes, graphite, hard carbon, and graphene.

14. The battery of Claim 12, wherein the silicon-containing material is selected from the group consisting of silicon nanotubes and fumed silica.

15. The battery of Claim 11, wherein the polymer binder has a molecular weight of 1,000 to 8,000,000 and is selected from the group consisting of unsaturated elastomers, saturated elastomers, thermoplastics, polyacrylic acid, polyvinylidene chloride, and polyvinyl acetate. poly(ethylene oxide), polystyrene, polyisobutylene, natural rubbers, butadiene rubbers, styrene-butadiene rubber, polyisoprene rubbers, butyl rubbers, hydrogenated nitrile butadiene rubbers, epichlorohydrin rubbers, acrylate rubbers, silicon rubbers, nitrile rubbers, polyacrylic acid, polyvinylidene chloride, polyvinyl acetate, ethylene propylene diene termonomer, ethylene vinyl acetate copolymer, ethylene-propylene copolymers, ethylene-propylene terpolymers, polybutenes, and wax.

16. The battery of Claim 11, wherein the solvent is selected from the group consisting of alkanes, toluene, ethylbenzene, cumene, xylene, sulfones, mineral oil, glymes, and isoparaffinic synthetic hydrocarbon solvents.

17. The battery of Claim 16 further including an artificial solid electrolyte interface layer on a surface of the anode.

18. The battery of Claim 17, wherein the artificial solid electrolyte interface is formed from the polymer binder and a lithium ion conducting additive.

19. The battery of Claim 18, wherein the lithium ion conducting additive comprises one or more solid electrolyte salts selected from the group comprising sulfides, oxides, phosphates, and argyrodite-type electrolytes.

20. The battery of Claim 1, wherein the anode active material is selected from the group consisting of graphite, hard carbon, graphite-SiO_x composite, SiO_x, SiO, SiO₂, SiC, Si, Si/C composite, Si-based alloys, graphite-SnO, Sn/C composite, and other lithium ion battery and lithium ion capacitor anode materials.

21. A battery comprising:

a cathode; and

a silicon-containing anode lithiated with a printable lithium composition comprised of a lithium metal powder, a polymer binder compatible with the lithium metal powder, a rheology modifier compatible with the lithium metal powder, and a solvent compatible with the lithium metal powder and with the polymer binder;

wherein a surface of the silicon anode is alloyed with lithium particles diffused from the printable lithium composition to form a porous layer on the surface that provides increased lithium conductivity and prevents lithium plating to enable fast charging of the battery.

22. A method of forming an anode comprising:

providing a slurry comprised of a silicon active material; and

adding to anode slurry a printable lithium composition comprised of a lithium metal powder, a polymer binder compatible with the lithium metal powder, a rheology modifier compatible with the lithium metal powder, and a solvent compatible with the lithium metal powder and with the polymer binder to form an anode slurry.

23. The method of Claim 22 further including coating the anode slurry onto a current collector.
24. The method of Claim 23 further including drying the solvent from the anode slurry to form an anode.
25. The method of Claim 24 further including forming a solid electrolyte interface layer within an initial 24 hour rest period.
26. The method of Claim 25, wherein the solid electrolyte layer is formed without a formation cycle.
27. The battery of Claim 1, where the printable lithium composition significantly reduces the formation time by forming a solid electrolyte interface layer during the rest step.