CLAIMS

1. A composite electrode comprising:

a silicon-based electrode;

a dielectric layer directly disposed on the silicon-based electrode, the dielectric layer having a dielectric layer thickness between 15 nanometers (nm) and 30 nm; and

a conductive layer disposed on the dielectric layer, the conductive layer and dielectric layer forming a layer pair, the conductive layer being made of a lithium containing salt that is highly conductive to lithium ions,

wherein the composite electrode has a resistivity less than 40 ohm-cm^2.

2. A composite electrode, as in Claim 1, with a charge-transfer time constant of less than 2.25E-6 seconds.

3. A composite electrode, as in Claim 1, where the dielectric layer thickness is between 18 nm and 23 nm.

4. A composite electrode, as in Claim 1, where the dielectric layer is made of a lithium compound.

5. A composite electrode, as in Claim 4, where the lithium compound is one or more of the following: lithium fluoride, LiF, lithium niobium oxide, lithium aluminate ($LiAlO_2$), lithium titanate (Li_2TiO_3), and lithium niobite ($LiNbO_3$).

6. A composite electrode, as in Claim 4, where the lithium compound is a lithiated version of one or more of the following: titanium dioxide, niobium oxide, rubidium oxide, tungsten oxide, aluminum oxide, zinc oxide, and zirconium oxide.

7. A composite electrode, as in Claim 1, where the where the dielectric layer is made of one or more of the following: titanium dioxide, niobium oxide, rubidium oxide, tungsten oxide, aluminum oxide, zinc oxide, and zirconium oxide.

8. A composite electrode, as in Claim 1, where the lithium containing salt is one or more of the following materials: lithium hexafluorophosphate, lithium perchlorate, lithium trifluoromethanesulfonate, lithium fluoride, $LiBF_4$, $LiBF_6$, lithium chloride, lithium phosphate compounds, lithium bromide compounds, lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium difluoro(oxalato)borate (LiDFOB), and lithium bis(oxalato)borate(LiBOB).

9. A composite electrode, as in Claim 1, where the conductive layer has a conductive layer thickness between 1 nm to 50 nm.

10. A composite electrode, as in Claim 1, where the silicon-based electrode is made of one or more of the following materials: a bulk silicon, a crystalline silicon, a non-crystalline silicon, a doped silicon, a boron doped silicon, a porous silicon, a non-porous silicon, a silicon germanium alloy, and a carbon-doped silicon-based alloy.

11. A composite electrode, as in Claim 1, further comprising an electrode contact made of one or more of the following: a conductive material, a metal, a metal nitride, tungsten (W), copper (Cu), titanium (Ti), platinum (Pt), nickel (Ni), aluminum (Al), gold (Au), and titanium nitride (TiN).

12. A composite electrode, as in Claim 1, where the layer pair is directly disposed on a silicon-based electrode so that a pair bottom surface of the layer pair is in direct physical and electrical contact with an electrode pair surface of the silicon-based electrode, and where the electrode interface is where the pair bottom surface and the electrode pair surface are in contact.

13. An energy storage device comprising:

a composite electrode as claimed in claim 1, wherein the layer pair is on a trench bottom of a trench in the silicon-based electrode;

an anode disposed on the composite electrode and within the trench;

an electrolyte layer disposed on the anode;

a cathode electrode disposed on the electrolyte layer; and

a separator layer preventing electrode flow between the anode and the cathode.

14. A device, as in Claim 13, where the electrolyte layer is one of the following: a solid polymer electrolyte (SPE), a solid electrolyte, a hybrid polymer/solid electrolyte, and a liquid electrolyte.

15. A device, as in Claim 13, composed of the composite have a charge-transfer time constant of less than 2.25E-6 seconds.

16. A device, as in Claim 13, where the silicon-based electrode is made of a boron doped crystalline silicon, the dielectric layer is made of LiF, the conductive layer is made of bis(trifluoromethanesulfonyl)imide (LiTFSI), and the electrolyte layer is made of a solid polymer electrolyte (SPE) which further is made from a mixture of polycaprolactone, succinonitrile (SN), and lithium bis(trifluoromethanesulfonyl)imide (LiTFSI).