CLAIMS

What is claimed is:

1. A battery module for starting engine of power equipment comprising:

a plurality of interconnected lithium-ion battery cells; wherein each of the lithium-ion battery cells independently comprises a cathode, an anode, a separator interposed between the cathode and anode, and an electrolyte; wherein the cathode comprises a cathode current collector and a cathode electrode layer comprising a cathode material, a binder material and a conductive agent, and the anode comprises an anode current collector and an anode electrode layer comprising an anode material, a binder material and a conductive agent;

wherein the cathode material comprises or is a core-shell composite having a core and shell structure, wherein the core comprises a lithium transition metal oxide selected from the group consisting of $LiMn_2O_4$, $Li_{1+z}Ni_xMn_yCo_{1-x-y}O_2$, $LiNi_xCo_yAl_zO_2$, and combinations thereof, wherein each x is independently from 0.3 to 0.8; each y is independently from 0 to 0.45; and each z is independently from 0 to 0.2; wherein the shell comprises a lithium transition metal oxide selected from the group consisting of $LiCoO_2$, $LiNiO_2$, $LiNi_xMn_yO_2$, $Li_{1+z}Ni_xMn_yCo_{1-x-y}O_2$, $LiNi_xCo_yAl_zO_2$, $LiMnO_2$, $LiMn_2O_4$, and combinations thereof, wherein each x is independently from 0.3 to 0.8; each y is independently from 0.1 to 0.45; and each z is independently from 0 to 0.2;

wherein the electrolyte comprises an organic solvent, a lithium salt, and an additive selected from the group consisting of diethylstilbestrol, butanesultone, vinylene carbonate, dimethyl sulfide, and combinations thereof; and

wherein the amount of the additive is from 0.1% to 2% by weight, based on the total weight of the electrolyte.

2. The battery module of claim 1, wherein the diameter of the core is from about 5 μm to about 45 μm and the thickness of the shell is from about 3 μm to about 15 μm.

3. The battery module of claim 2, wherein the ratio of the diameter of the core to the thickness of the shell is from 5.7 to 12.6.

4. The battery module of claim 1, wherein the lithium transition metal oxide in the core is doped with a doping element selected from the group consisting of Fe, Ni, Mn, Al, Mg, Zn, Ti, La, Ce, Sn, Zr, Ru, Si, Ge, and combinations thereof.

5. The battery module of claim 1, wherein the lithium transition metal oxide in the shell is doped with a doping element selected from the group consisting of Fe, Ni, Mn, Al, Mg, Zn, Ti, La, Ce, Sn, Zr, Ru, Si, Ge, and combinations thereof.

6. The battery module of claim 5, wherein the doping element is Al.

7. The battery module of claim 5, wherein the doping element is present in an amount less than 2% by weight, based on the total weight of the cathode electrode layer.

8. The battery module of claim 5, wherein the content of the doping element gradiently decreases from the outer surface of the shell to the inner core.

9. The battery module of claim 1, wherein each of the core and shell independently comprises two or more lithium transition metal oxides.

10. The battery module of claim 9, wherein the two or more lithium transition metal oxides in the core and shell are different.

11. The battery module of claim 9, wherein the two or more lithium transition metal oxides are not uniformly distributed over the core.

12. The battery module of claim 1, wherein the cathode material has a particle size D50 from about 10 μm to about 50 μm.

13. The battery module of claim 1, wherein the conductive agent of the cathode electrode layer comprises carbon nanotube and graphene.

14. The battery module of claim 1, wherein the amount of each of the cathode and anode materials is independently between 80% and 95% by weight, based on the total weight of the cathode electrode layer or anode electrode layer, and wherein the amount of each of the conductive agents and binder materials in the cathode and anode electrode layers is independently from about 3% to about 10% by weight, based on the total weight of the cathode electrode layer or anode electrode layer.

15. The battery module of claim 1, wherein the density of each of the cathode and anode electrode layers is independently from about 1.0 g/cm^3 to about 6.5 g/cm^3.

16. The battery module of claim 1, wherein the additive is diethylstilbestrol and vinylene carbonate.

17. The battery module of claim 16, wherein the amounts of diethylstilbestrol and vinylene carbonate are respectively 0.5% and 1.5% by weight, based on the total weight of the electrolyte.

18. The battery module of claim 1, wherein the separator has a melting point of 200 °C or higher.

19. The battery module of claim 1, wherein the separator comprises a porous base material and a protective porous layer coated on one or both surfaces of the porous base material, and wherein the protective porous layer comprises a binder material and an inorganic filler selected from the group consisting of Al_2O_3, SiO_2, TiO_2, ZrO_2, BaO_x, ZnO, $CaCO_3$, TiN, AlN, and combinations thereof, wherein x is 1 or 2.

20. The battery module of claim 1, wherein each of the lithium-ion battery cells independently comprises a first conductive tab coupled to the cathode and a second conductive tab coupled to the anode, and wherein the width of each of the first and second conductive tabs is independently greater than 2 cm.