Design Considerations Using Lithium Polymer Batteries

Dr. Robin Tichy, Micro Power Electronics

Li-ion cells come in three basic form factors: cylindrical, prismatic (rectangular brick shape) and the flat Lithium polymer cells. Lithium polymer cells, sometimes called laminate cells, are available in custom footprint size. They can be very thin or quite large depending on their intended use. The primary advantage of Lithium polymer batteries is the variety of form factors available. Manufacturers of blue tooth devices were the first to recognize the advantage of Lithium polymer batteries. The availability of very thin batteries enabled the Motorola Razr phone to have great market success. Apple created a thin notebook which differentiated it in the highly commoditized notebook market.

History of Lithium Polymer Cells

The three primary functional components of a Li-ion battery are the anode, cathode, and electrolyte, for each of which a variety of materials are used. At one time a polymer battery had a solid polymer electrolyte such as Polyethylene oxide and a salt, but no liquid electrolyte. Cells using these solid polymer electrolytes typically had lithium metal anodes which become unstable during cycling. The other problem with these solid polymers is that they have poor conductivity at room temperature. These two factors prevented any mass commercialization of that technology. In the 90's, Bellcore Labs came up with a Li-ion battery that used a cast porous polymer film to bind the electrodes together as well as electrically insulating them from each other. Liquid electrolyte was added and then gelled to bind it into the polymer matrix to some degree. Many companies tried and failed to commercialize this process, although some aspects of it are used in Lithium polymer cells today.

Today's Lithium polymer cells are more closely related to other Li-ion cells. Their defining feature is a flexible, foil-type (polymer laminate) exterior. There are a wide array of different technologies used to produce these batteries - some have liquid electrolytes, some are gelled by inclusion of polymers in the electrolyte, some have the layers laminated together and others may be have their electrodes stacked rather than wound. The chemistry is the same as Li-ion. Basically, it is a Li-ion battery in a soft pack.

Lithium Polymer Manufacturing Process

Because the chemistry and internal structure is the same as for conventional Li-ion cells, the front end of the manufacturing process is essentially unchanged. All of the same automated high-throughput equipment can be used. Where the process diverges is from conventional cells is assembly; Lithium polymer assembly tends to be semi-automatic giving it the advantage of faster and less expensive conversion to new cell sizes versus the highly automated cylindrical cell process which makes changing sizes very expensive and time-consuming. Polymer assembly lines can also be fully automated, but then lose some of the size flexibility. The first step of assembly is forming pouches for the cells. In the middle of the laminate is an aluminum layer that serves as a moisture barrier, the same function as in food packaging. Since Li-ion cells will react with moisture, this layer is vital for long life in the battery. Once the pouches are formed, the jelly rolls or decks are inserted and then heat sealed, leaving an opening for electrolyte filling. The electrolyte is then filled and the opening to the package is sealed. The first image compares the two types of cell construction.

Avantages of Lithium Polymer Batteries

They can be made very thin, down to around half a millimeter. However, much of the space is wasted by the packaging at the bottom of this range so cells typically range from 2 to 6.5mm thick.

•The length and width can be made quite large. Cell capacities can range anywhere from up to 10Ah.

•The lack of a metal can allows more flexibility to change sizes per customer requirement.

Disadvantages of Lithium Polymer Batteries

•Their flexibility does come at a small cost premium.

•The soft packaging on polymer cells is easily punctured and has more swelling than metal cans.

•Another disadvantage of a Lithium polymer cell compared to a cylindrical cell is less volumetric energy density. However, this disadvantage in energy density can be overcome by the advantage in packing density.

Performance and Other Considerations

The voltage profile does not depend on the packaging but on the active materials inside. Both Lithium polymer and prismatic cells tend to have better cycle life than cylindrical cells because they are not so tightly constrained, allowing the electrodes to expand and contract more freely during cycling. The second figure is a graph of the cycle life of a 2.7Ah cell. It is still retaining 90% after 500 cycles. There are newer designs coming that achieve 95% after 500 cycles, and should exceed 1000 cycles.

Puncturing a cell is a much larger risk for a Lithium polymer cell compared to one in a steel or aluminum can. A punctured cell can cause an internal short circuit, which will cause the cell to get hot. Special care must be made in handling the cells and in the pack design so that there are no sharp objects that could come into contact with the cells.

Edge shorting is another often overlooked issue. The aluminum layer in the packaging is conducting so if it is exposed at the cut edges of the package, it can short out components that are put in contact with it.

Over-discharge and over-charge damage is an issue for all Li-ion cells but the resultant gassing in Lithium polymer cells is more obvious.

The battery pack has special features also as can be seen in this third image. Since the cells are not rigid, ribbing is put between cells to prevent crushing and twisting of the pack. Resistance welding to the tabs is recommended to prevent heat from soldering from melting the cell’s packaging. The cells need to be secured within the enclosure to prevent shifting during shock and vibration .Stacking the cells prevents issues caused by cell swelling. The thermistor needs to be against the cell but away from areas most likely to swell. External short circuit and over-temperature protection is required on the battery management circuit board since there is no PTC or short circuit protection within the cell.

Conclusion

Lithium polymer batteries are predicted to become quite common with manufacturers producing 1 billion cells per year by the end of this decade. Lithium polymer batteries have become common in single-cell consumer applications like cell phones and MP3 players, but industrial and commercial applications are now putting them to good use as well. The thin and custom shaped cells are now used in large, complex packs.

Dr. Robin Tichy is Technical Marketing Manager for Micro Power Electronics, www.micro-power.com