The Impact of Cell Geometries and Battery Designs on Safety and Performance of Lithium Ion Polymer Batteries

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The most common cell geometry practiced in lithium ion batteries is wound design. For cylindrical cells the battery structure is naturally a jelly roll. For rectangular cells, round jelly rolls are typically flattened, to be called as flat wound pseudo-prismatic designs. Although adequate in relatively thick rectangular cells where enough stack pressure is applied by metal cans, this design poses problems for thinner cells. As battery becomes slimmer, the metal enclosure cannot exert enough pressure onto the electrode stacks, resulting in poor thickness control. This situation is further aggravated by the electrode distortion occurring during charge and discharge cycles [1]. All these problems are even more vivid in polymer batteries where laminated aluminum sheet is used as cell case. As an alternative to jelly roll designs, and in order to circumvent the related shortcomings, true flat plate structures have been developed and adopted by many battery manufacturers [2,3].

In this investigation we have examined various ways of electrode stacking configurations along with conventional wound construction. In order to compare truly structural effects, electrode materials and cell components were fixed. Detailed material descriptions and test conditions are given in previous works [1,2]. Identical battery enclosure (laminated aluminum pouch) were used throughout this study. Battery size under consideration was 3.8 mm x 35mm x 62mm for commercial cell phone applications. For jelly roll fabrication, electrodes and separators were cut into strips, layered and rolled into flat jelly rolls (Figure 1). For the various stacked designs shown in Figures 2 and 3, electrodes were cut and laminated onto gelling polymer coated separators [4] in predetermined gaps and folded into different styles according to the schematics shown in Figures 2 and 3.

The advantages we have found of flat-plate designs can be summarized as: i) true flat shape that helps to keep the battery thickness uniform and thin, ii) inherently higher energy densities due to lesser dead volume within the cell enclosure, iii) lower cell impedance resulting from plurality of electrical contacts through electrode tabs. We also noticed for the stacked cells, the manner in which each cell is folded with separator materials dictates abuse safeties at elevated temperatures such as hot box and overcharge. During high temperature events, it was observed that short circuits that may occur around the electrode edges can trigger safety events more easily. Free stack structures without any folding options inevitably allow the separator materials to contract when exposed to shutdown temperatures. Although inherent thermal properties of electrolytes and electrode materials are important, cell designs must also be considered for safer lithium ion battery developments.

References

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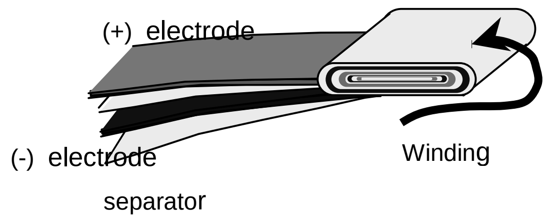

Figure 1. Conventional Flat Wound Jelly Roll Structure

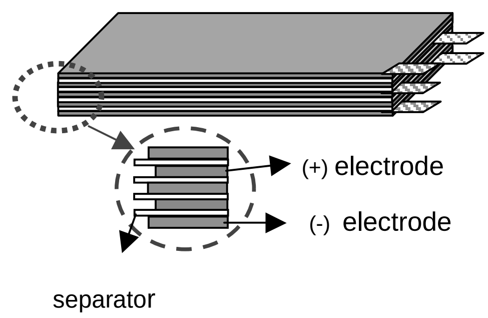

Figure 2. Plain Stacked-Electrode Structure

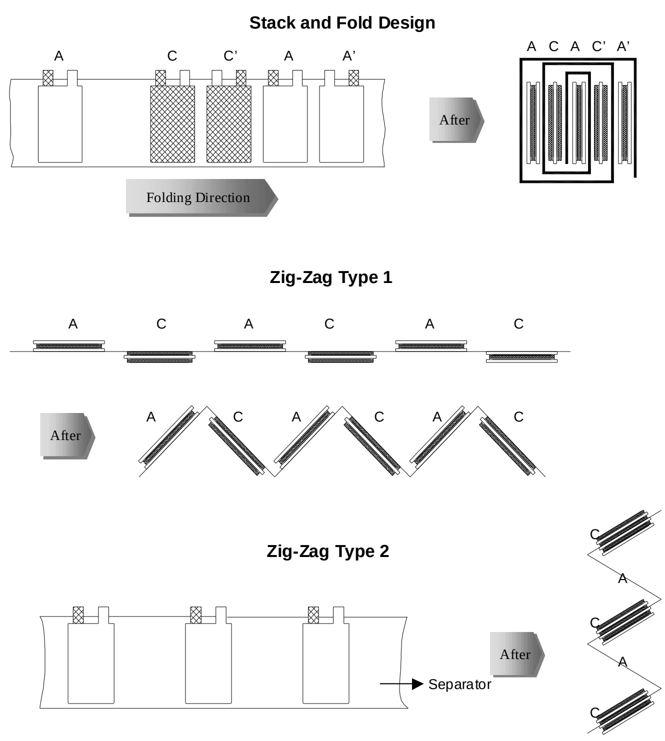

Figure 3. Variations in Stack and Fold Designs