Safety in Lithium Ion Batteries: State of the Art in Separators

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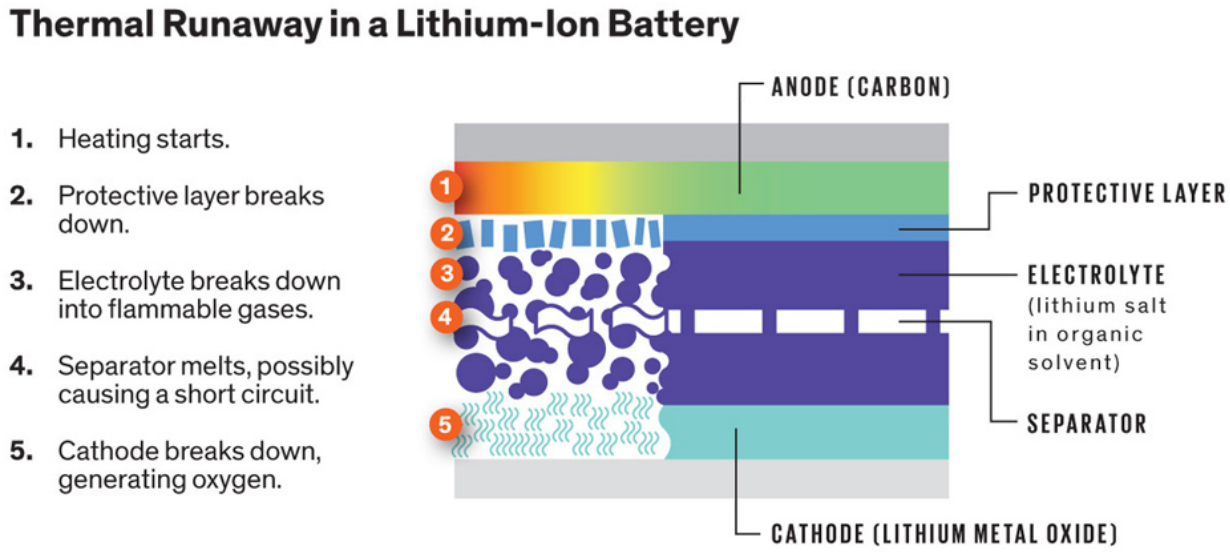
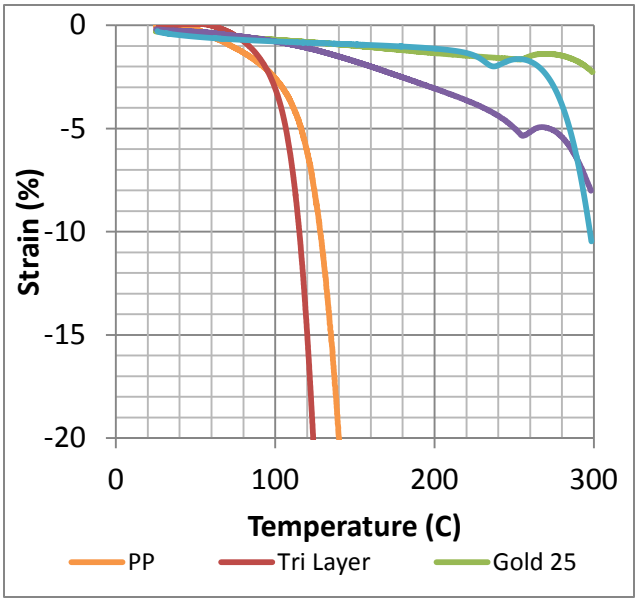
ABSTRACT

It has been said that lithium ion batteries are a lot of energy packed into a small package, which can also be said of a grenade. So if there is a lot of energy, what causes them to go into thermal runaway and uncontrolled decomposition? As the battery heats, first the protective layer on the anode breaks down, then the anode will facilitate breakdown of the electrolyte into flammable gasses, then the separator melts, allowing a short circuit which ignites the gasses. This talk will focus on the separator melting and shrinking, and how this can be improved to increase the safety of the cell.



Predominant lithium ion battery separators are made from polyolefins, either polypropylene or polyethylene. These materials undergo catastrophic shrinkage above 120 C, which leads to shorting in cells that can cause the sparks that will ignite the electrolyte and flammable gasses. Several methods have been proposed to improve the thermal stability of separators, which include:

- Ceramic coating: Invented by Celgard in 2000, a coating of ceramic particles and polymer binder is coated on one or both sides of the separator, reducing the



shrinkage, but increasing resistance and thickness.

- Ceramic reinforcement: Several companies have produced products that reinforce the walls of the separator with ceramic particles, reducing the shrinkage and increasing the thermal stability.
- Polyimide nanofibers: Dupont introduced a polyimide nanofiber based separator with stability up to 500 C and very high porosity.
- Nanofiber/microfiber combinations: Dreamweaver has introduced a wet-laid nonwoven material made from a combination of nanofibers and microfibers

These different separator performances can have a dramatic influence on when and how a battery undergoes a thermal event. As an extreme test, samples of different materials were saturated with electrolyte and exposed to flame. The during and after pictures are shown in the figure below. The current technology polyolefin separator shrinks and burns, while separators that are designed for advanced thermal performance are able to hold their shape even at the extreme burning temperatures of the fire.

In summary, separators play a significant role in the thermal safety of lithium ion cells, which is critically important in applications from aerospace to portable electronics to electric vehicles. We discuss here the state of the art of thermally stable separators and their performance in cells; which is the eventual leader in the cells of the future has yet to be determined.