

# A Structure of Cylindrical Lithium-ion Batteries

## Introduction

A lithium-ion battery is an energy storage device providing electrical energy by using chemical reactions. A few types of lithium-ion battery cells have been used widely as shown in Figure 1. With the cylindrical cell format, the batteries can be applied to many applications, for example, power tools, laptops, portable electronic devices and electric vehicles. Figure 2 shows cylindrical lithium-ion batteries in a laptop and a power tool. For an electric vehicle, the battery system of the Tesla roadster is comprised of 6,831 cylindrical lithium-ion cells (Eberhard). The cylindrical cells have high energy density, high power, as well as high performance and long calendar life.



Figure 1: Types of lithium-ion battery cells: coin cells<sup>1</sup> (left), cylindrical cells<sup>2</sup> (middle) and a pouch cell<sup>3</sup> (right)



Figure 2: Cylindrical lithium-ion batteries in a laptop<sup>4</sup> (left) and a power tool<sup>5</sup> (right)

<sup>1</sup> Source: [http://batteryuniversity.com/learn/article/types\\_of\\_battery\\_cells](http://batteryuniversity.com/learn/article/types_of_battery_cells)

<sup>2</sup> Source: <http://na.industrial.panasonic.com/products/batteries/rechargeable-batteries>

<sup>3</sup> Source: <http://www.a123systems.com/prismatic-cell-amp20.htm>

The purpose of this document is to introduce a structure of a cylindrical lithium-ion cell. Figure 3 demonstrates a structure of a cylindrical lithium-ion battery cell. The components in the cylindrical cell can be classified into three major groups: a jellyroll, current connectors, and safety devices. The rest of the document is organized as follows. A jellyroll of a positive electrode, a negative electrode and separators is introduced. The current connectors of the cylindrical cell are introduced. Moreover, safety devices implemented in the cylindrical cell are described. Finally, the conclusion summarizes a structure of cylindrical lithium-ion batteries.

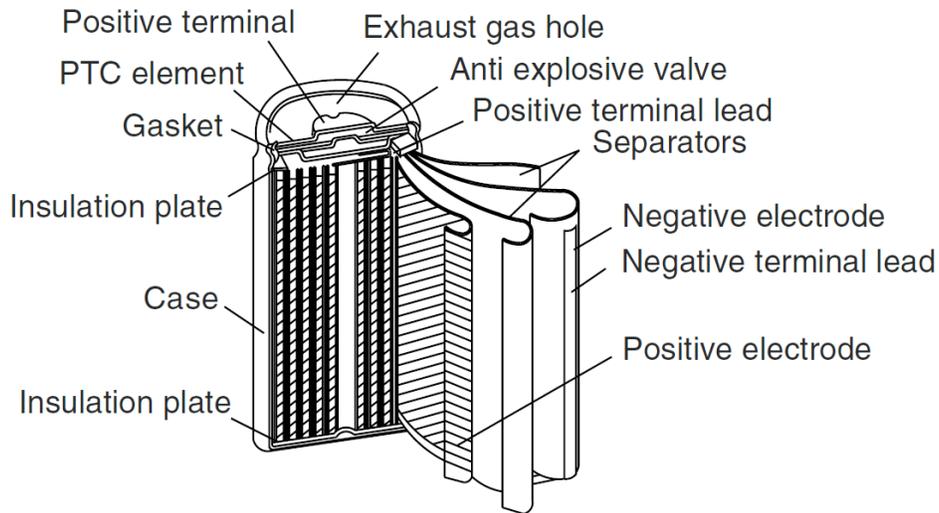


Figure 3: A structure of a cylindrical lithium-ion battery cell<sup>6</sup>

## A Jellyroll

A jellyroll design is used to fabricate a positive electrode, a negative electrode, and two separators into a cylindrical can. After finish electrode sheet preparations, the jellyroll fabrication begins with layering down a separator sheet then a layer of a negative electrode, a separator sheet and a positive electrode, respectively. Then, the sandwich is rolled up to make an electrochemical cell for a cylindrical cell. More details of each layer are provided below:

- **Positive electrode**

The positive electrode or the cathode is a compound of materials coating on an aluminum foil. Common cathode materials are Lithium Cobalt Oxide ( $\text{LiCoO}_2$ ), Lithium Manganese Oxide ( $\text{LiMnO}_2$ ), Lithium Iron Phosphate ( $\text{LiFePO}_4$ ), Lithium Nickel Manganese Cobalt Oxide (or NMC) and Lithium Nickel Cobalt Aluminum Oxide (or NCA).

- **Negative electrode**

The negative electrode or the anode is a compound of carbon materials coating on a copper foil. Graphite is the most popular use for the carbon materials.

<sup>4</sup> Source: <http://laptopbatteryone.com/common/pagedetail.aspx?pagecode=batterycomparison>

<sup>5</sup> Source: <http://www.ebay.com/itm/for-Sanyo-3-6V-20A-1-5Ah-UR18650WX-UR-18650-WX-Power-Battery-Cell-Lithium-Li-ion-/221077263893>

<sup>6</sup> Source: "Panasonic: Lithium Ion Technical Handbook," 2007

- **Separators**

A separator is a very thin porous plastic sheet used to insulate between two electrodes. The separator allows lithium-ion atoms pass through but does not allow electrons pass through it. The separator is required to have high porosity, thin sheet, as well as the ability to be soaked in electrolyte. The thickness of separators is typically on the order of 20 micrometer. A separator can be made of polyethylene (PE), polypropylene (PP), or composite materials of PE and PP.

## **Current Connectors**

Current connectors are conductive materials used to transmit electrons from a device to another device. A cylindrical lithium-ion battery cell consists of four current connectors:

- **Positive terminal**

A positive terminal is a conductive material used to connect the positive terminal of the cylindrical cell to the positive terminal of a device. The positive terminal is the projection at the top of the battery. Most positive terminal materials are stainless steel. The stainless steel has high strength and high corrosion resistant.

- **Negative terminal**

A negative terminal is a conductive material used to connect the negative terminal of the battery cell to the negative terminal of a device. The negative terminal is located at the bottom of the battery cell. Stainless steel is often used for manufacturing the negative terminal.

- **Positive terminal lead**

A positive terminal lead is a thin strip of metal used to connect the positive electrode with the positive terminal. The positive terminal lead is made from aluminum alloys.

- **Negative terminal lead**

A negative terminal lead is a thin strip of metal used to connect the negative electrode with the negative terminal. Many manufacturers often use a can case as a negative terminal. Hence, the negative terminal lead typically is welded to the cylindrical can. Nickel alloy typically is used for fabricating the negative terminal lead.

## **Safety Devices**

Safety devices are very important for using any types of lithium-ion batteries because lithium is highly energetic materials and electrolyte is flammable. Therefore, manufacturers implement several safety devices into cylindrical lithium-ion battery cells.

- **Case**

A case is a portable container for carrying and covering the jellyroll. The electrodes and the separators are very thin and soft materials. They can be deformed easily by applying small

forces. The can must have ability to withstand external forces and internal pressures without deforming. Stainless steel is typically used for manufacturing a can.

- **Insulation plate**

An insulation plate is a thin circular plastic sheet used to prevent short circuit between two conductors. There are two insulation plates in the cylindrical cell. The first plate is located between the bottom of the jellyroll and the bottom of the can. The second plate is located between the top of the jellyroll and the gasket.

- **Gasket**

A gasket is an insulating material used to tightly fill a space between the can and the positive terminal. At the final step of the cylindrical cell fabrication, the cap of the cell is compressed by high compression load to seal the can with the cap. Because the can is connected to the negative terminal lead, the gasket is used to prevent the transmission of electricity between the positive terminal and the negative terminal. The gasket is also required to have ability to withstand high compressive loads.

- **Positive Temperature Coefficient (PTC) element**

A positive temperature coefficient element is a conductive composite material used to protect the batteries by limiting current at high temperatures. When the temperature of the batteries is above the cut-off temperature, the resistance of the PTC will be increased significantly. The current going in or out of the batteries will be decreased. The PTC element is located between the positive terminal and the anti-explosive valve.

- **Anti-explosive valve**

An anti-explosive valve is a mechanical device used to prevent an explosion of the batteries. When the pressure inside the can is increased dramatically, the anti-explosive valve will be broken by the internal pressure force. The internal circuit of the batteries will be opened. Therefore, the batteries cannot be used anymore. The anti-explosive valve is located between the PTC element and the insulation plate.

- **Exhaust gas hole**

Exhaust gas holes are a venting mechanism used to release excess gases when the anti-explosive valve is opened. The holes are located at the positive terminal of the battery. Gases inside the cylindrical cell are generally generated from unusual operation, for example, overcharging, physical cell damage, and internal short-circuits.

## **Conclusion**

A lithium-ion battery is an electrochemical energy storage device. Cylindrical Lithium-ion Batteries have been used in many electronic devices. The electrochemical cell of the batteries consists of a layer of positive electrode, a layer of negative electrode and two layers of separator. To assemble the electrochemical cell into a case of the battery, these layers are rolled up to make a jellyroll. Current connectors including a positive terminal lead, a positive terminal, a negative terminal lead, and a negative terminal enable users to use electrical energy from the batteries. To use the batteries safely, a

number of safety devices are assembled into the structure of the cylindrical cell including a case, insulation plates, a gasket, a positive element, an anti-explosive valve, and an exhaust gas hole.

### **Bibliography**

*7 Laptop Battery Secrets You Should Know!* (n.d.). Retrieved from Laptop Battery One:

<http://laptopbatteryone.com/common/pagedetail.aspx?pagecode=batterycomparison>

*AMP20 Lithium Ion Prismatic Cell.* (n.d.). Retrieved from A123 Systems:

<http://www.a123systems.com/prismatic-cell-amp20.htm>

*Batteries: Rechargeable Batteries.* (n.d.). Retrieved from Panasonic:

<http://na.industrial.panasonic.com/products/batteries/rechargeable-batteries>

Eberhard, M. (n.d.). *A Bit About Batteries.* Retrieved from Tesla Motor:

<http://www.teslamotors.com/blog/bit-about-batteries>

*Power Battery Cell Lithium Li-ion.* (n.d.). Retrieved from ebay: [http://www.ebay.com/itm/for-Sanyo-3-](http://www.ebay.com/itm/for-Sanyo-3-6V-20A-1-5Ah-UR18650WX-UR-18650-WX-Power-Battery-Cell-Lithium-Li-ion-/221077263893)

[6V-20A-1-5Ah-UR18650WX-UR-18650-WX-Power-Battery-Cell-Lithium-Li-ion-/221077263893](http://www.ebay.com/itm/for-Sanyo-3-6V-20A-1-5Ah-UR18650WX-UR-18650-WX-Power-Battery-Cell-Lithium-Li-ion-/221077263893)

*Types of Battery Cells.* (n.d.). Retrieved from Battery University:

[http://batteryuniversity.com/learn/article/types\\_of\\_battery\\_cells](http://batteryuniversity.com/learn/article/types_of_battery_cells)