

What exactly is Lithium-Ion Battery?

Batteries definition:

Two or more electrochemical cells, electrically interconnected, each of which contains two electrodes and an electrolyte. The redox (oxidation-reduction) reactions that occur at these electrodes convert electrochemical energy into electrical energy.

In everyday usage, 'battery' is also used to refer to a single cell. The solid-state batteries are the batteries in which the electrolyte is in solid state, which is responsible for the conduction of ions from one electrode to other electrode.

In 1800, Alessandro Volta invented the first modern battery.

Types of Batteries

Basically, batteries can be classified as two types, primary batteries and secondary batteries.

Primary batteries

In primary batteries, the electrochemical reaction is not reversible. During discharging the chemical compounds are permanently changed and electrical energy is released until the original compounds are completely exhausted. Thus the cells can be used only once.

Secondary

In secondary batteries, the electrochemical reaction is reversible and the original chemical compounds can be reconstituted by the application of an electrical potential between the electrodes injecting energy into the cell. Such cells can be discharged and recharged many times.




Lithium Battery

- ✚ Lithium is the lightest of metals and it can float on water.
- ✚ The electrochemical properties of lithium are excellent and it is also a highly reactive material.
- ✚ These properties gives Lithium the potential to achieve very high energy and power densities in high-density battery applications such as automotive and standby power.
- ✚ Lithium batteries are primary batteries in which lithium metal (or) lithium compound acts as a Anode. A lithuim cell can produce voltage from 1.5 V to about 3 V based on the types of materials used.

Types of Lithium based Batteries

There are two types of lithium-based batteries available.

1. Lithium batteries
2. Lithium-ion batteries

-  In lithium batteries, a pure lithium metallic element is used as anode. These types of batteries are not rechargeable.
-  In lithium-ion batteries, lithium compounds are used as anode.
-  These batteries are known as re-chargeable batteries. Therefore, Lithium ion batteries are considered as best than pure Lithium based batteries.

Lithium-Ion Battery

Li-ion batteries are secondary batteries.

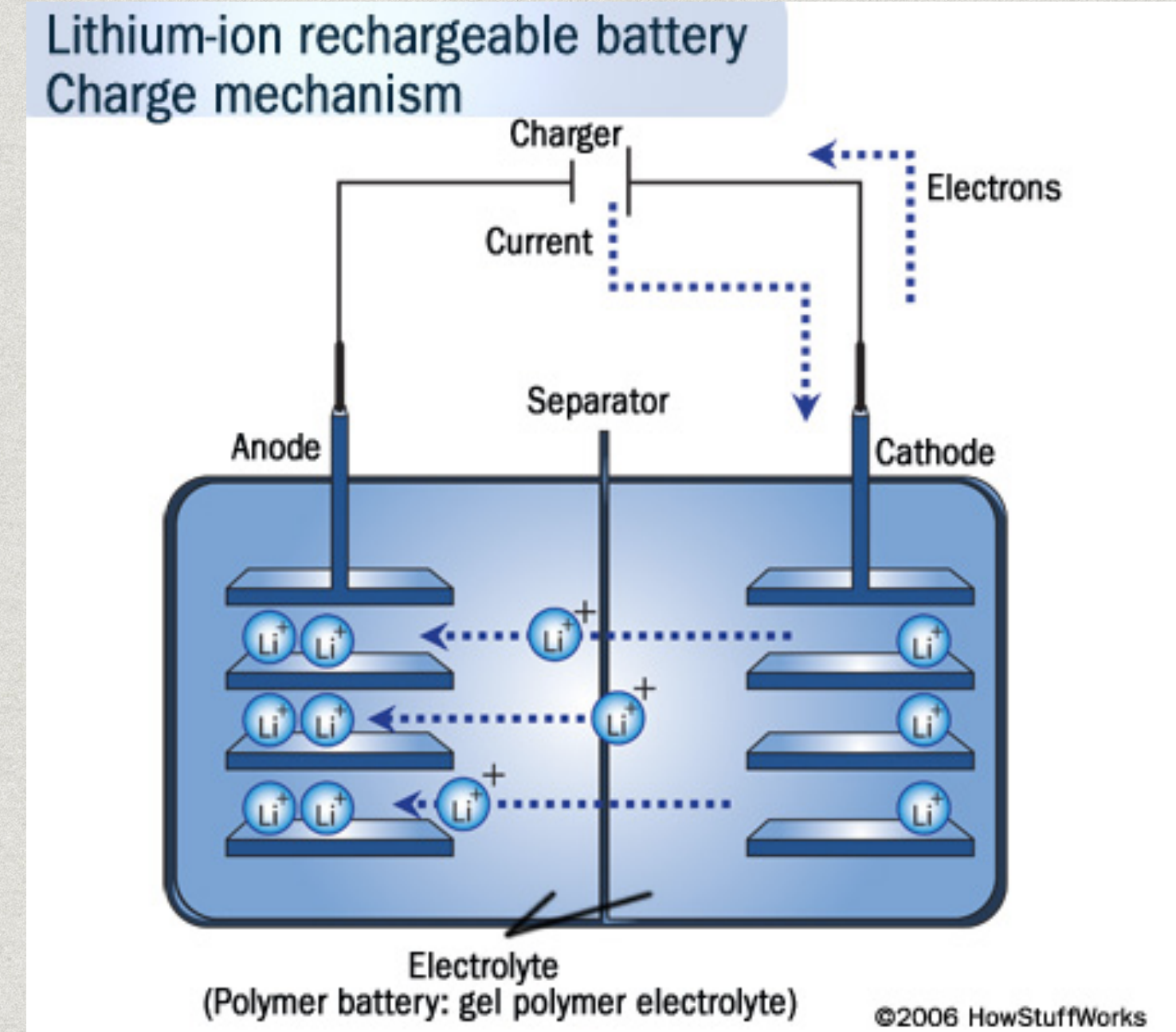
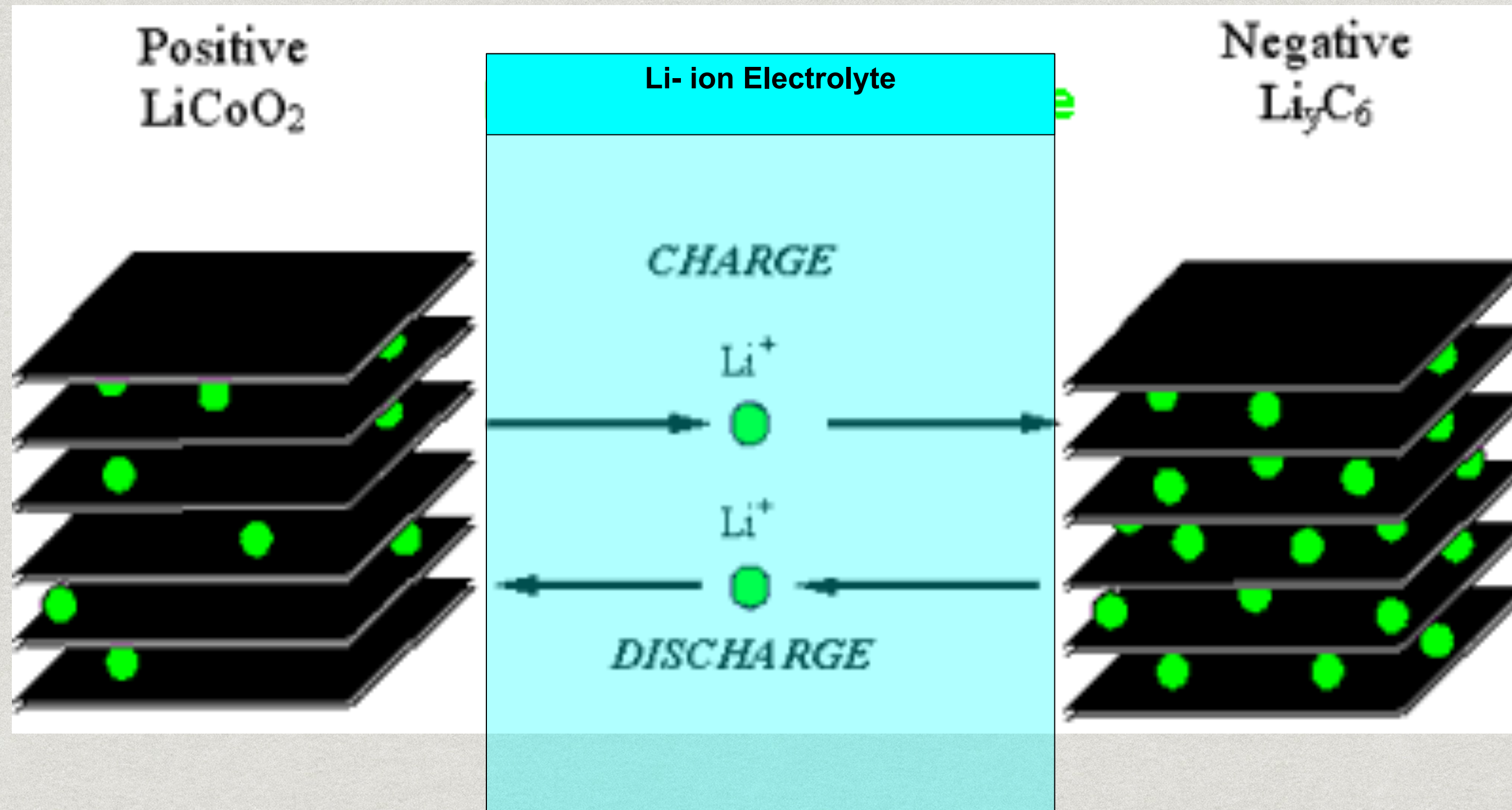
- The battery consists of an anode of Lithium, dissolved as ions, into a carbon.
- The cathode material is made up from Lithium liberating compounds, typically the three electro-active oxide materials,
 - Lithium Cobalt-oxide (LiCoO_2)
 - Lithium Manganese-oxide (LiMn_2O_4)
 - Lithium Nickel-oxide (LiNiO_2)

Lithium-ion batteries are common in home electronics. They are one of the most popular types of rechargeable batteries for portable electronics, with a high energy density, tiny memory effect and low self-discharge.

Principle of Working

- ✚ During the charge and discharge processes, lithium ions are inserted or extracted from interstitial space between atomic layers within the active material of the battery.
- ✚ Simply, the Li-ion is transfers between anode and cathode through lithium Electrolyte.
- ✚ Since neither the anode nor the cathode materials essentially change, the operation is safer than that of a Lithium metal battery.

Principle of Working



Construction of Li-ion Battery

- ✚ Li-ion cell has a four-layer structure.
- ✚ A positive electrode made with Lithium Cobalt Oxide has a current collector made of thin aluminum foil - **cathode**
- ✚ A negative electrode made with specialty carbon has a current collector of thin copper foil – **anode**
- ✚ A **separator** is a fine porous polymer film.
- ✚ An **electrolyte** made with lithium salt in an organic solvent.
- ✚ The electrolytes are selected in such a way that there should be an effective transport of Li-ion to the cathode during discharge.
- ✚ The type of conductivity of electrolyte is ionic in nature rather than electronic

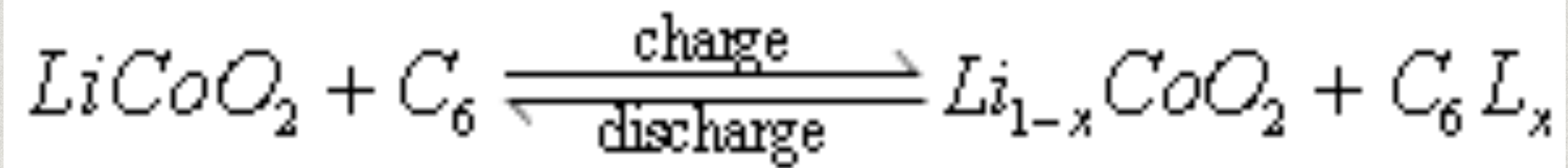
Working of Li-ion Batteries

The traditional batteries are based on galvanic action but Lithium ion secondary battery depends on an "intercalation" mechanism.

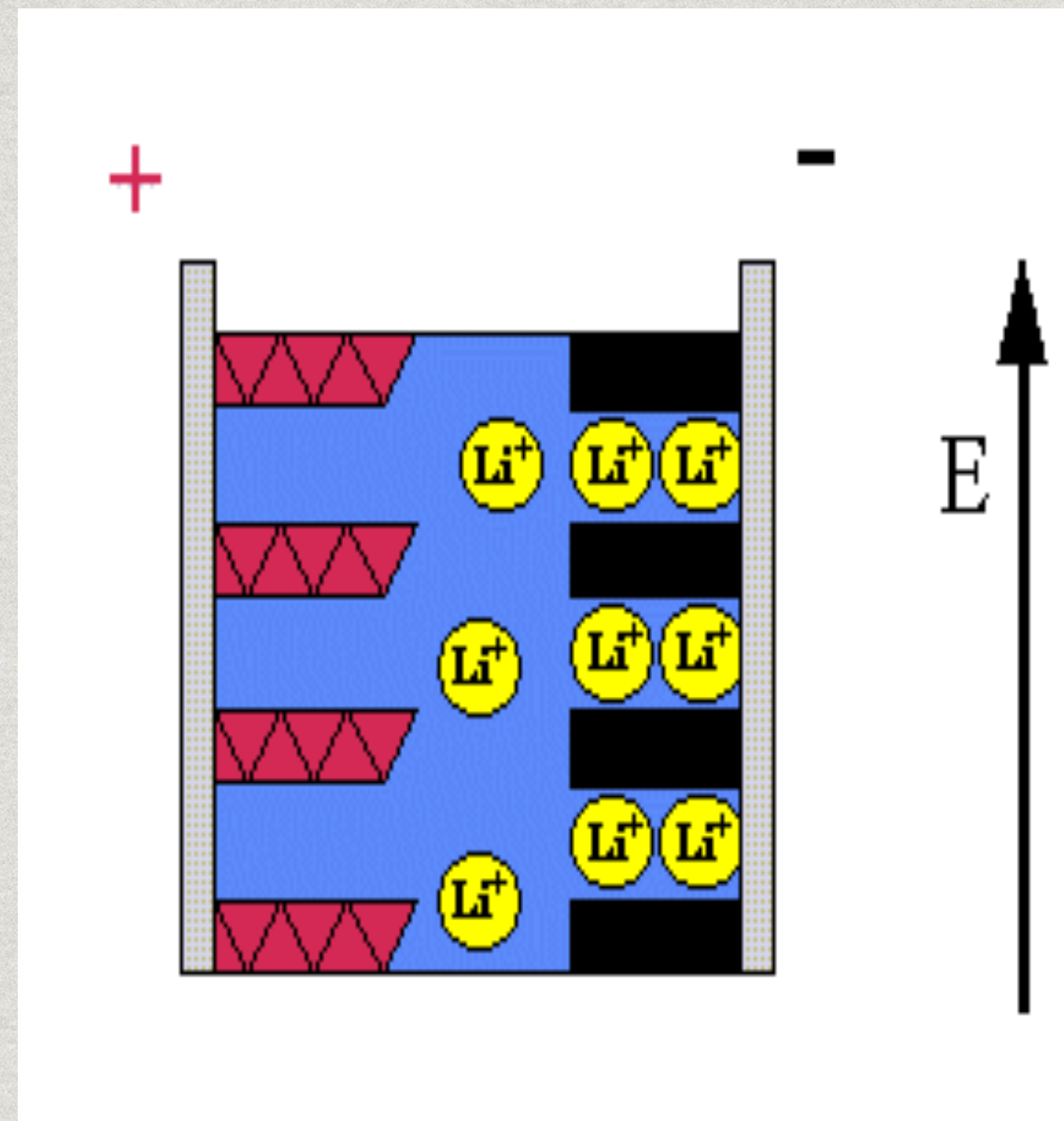
This involves the insertion of lithium ions into the crystalline lattice of the host electrode without changing its crystal structure.

These electrodes have two key properties. One is the open crystal structure, which allow the insertion or extraction of lithium ions and the second is the ability to accept compensating electrons at the same time. Such electrodes are called intercalation hosts.

The chemical reaction that takes place inside the battery is as follows, during charge and discharge operation:



Working of Li-ion Batteries

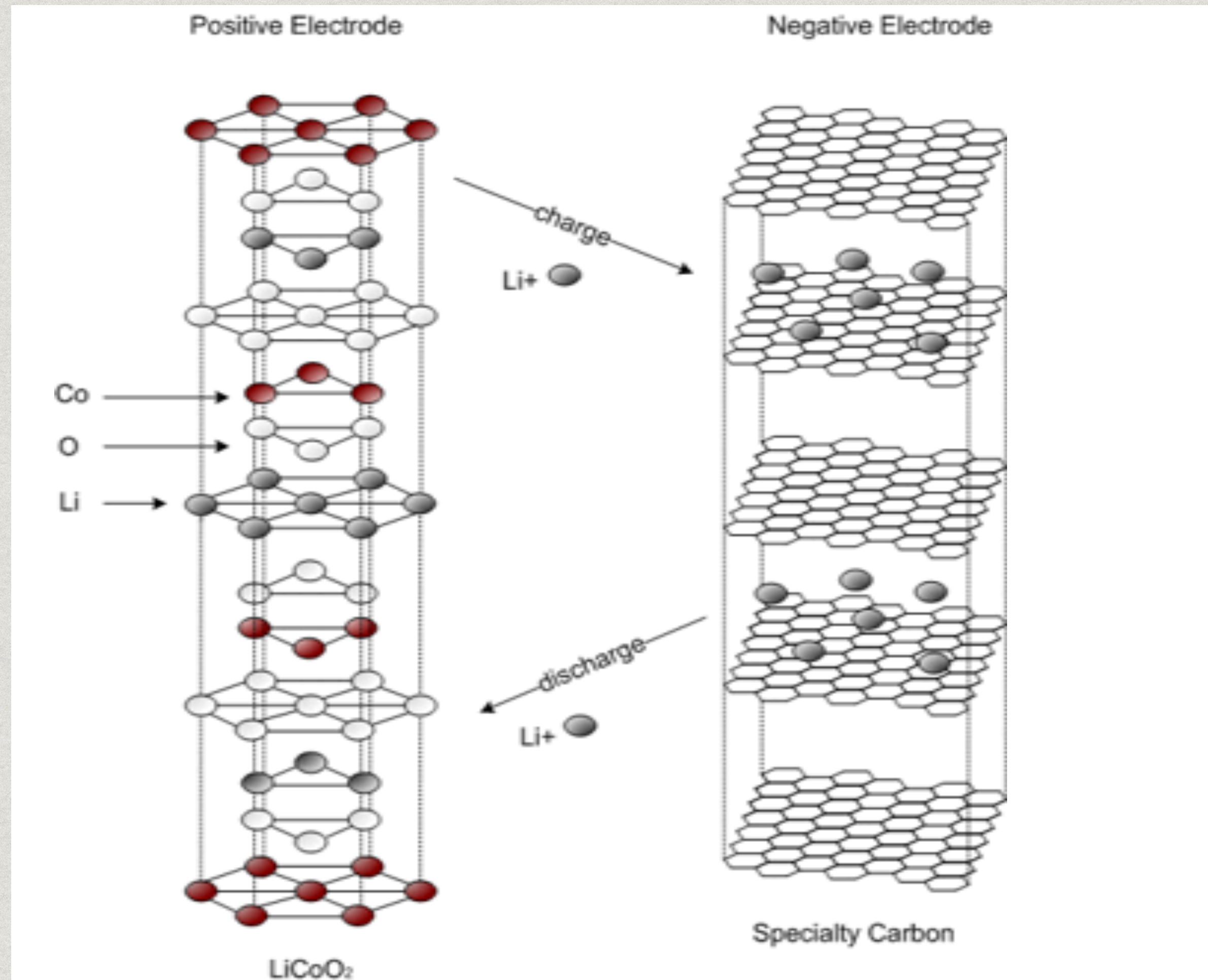


The lithium ion is inserted and exerted into the lattice structure of anode and cathode during charging and discharging.

During discharge current flows through external circuit and light glows

During charging, no the electrons flows in the opposite direction

Working of Li-Ion Batteries



- During charging, lithium in positive electrode material is ionized and moves from layer to layer and inserted into the negative electrode.

- During discharge Li ions are dissociated from the anode and migrate across the electrolyte and are inserted into the crystal structure of the host compound of cathode.

Working of Li-ion batteries

- At the same time the compensating electrons travel in the external circuit and are accepted by the host to balance the reaction.
- The process is completely reversible. Thus the lithium ions pass back and forth between the electrodes during charging and discharging.
- Because of this reason, the lithium ion batteries are called 'Rocking chair, 'Swing' cells.
- A typical Li-ion battery can store 150 watt-hours of electricity in 1 kilogram of battery as compared to lead acid batteries can store only 25 watt-hours of electricity in one kilogram
- All rechargeable batteries suffer from self-discharge when stored or not in use.
- Normally, there will be a three to five percent of self-discharge in lithium ion batteries for 30 days of storage.

Advantages of Li-ion Batteries

- They have high energy density than other rechargeable batteries
- They are less weight
- They produce high voltage out about 4 V as compared with other batteries.
- They have improved safety, i.e. more resistance to overcharge
- No liquid electrolyte means they are immune from leaking.
- Fast charge and discharge rate

Disadvantages

- They are expensive
- They are not available in standard cell types.

Applications of Li-ion Batteries

- The Li-ion batteries are used in cameras, calculators, smart phones and most of the consumer electronics device.
- They are used in cardiac pacemakers and other implantable device.
- Electric vehicles: Because of their light weight Li-ion batteries are used for propelling a wide range of electric vehicles such as aircraft, electric cars, Pedelecs, hybrid vehicles, advanced electric wheelchairs, radio-controlled models, model aircraft and the Mars Curiosity rover.
- Power tools: Li-ion batteries are used in tools such as cordless drills, sanders, saws and a variety of garden equipment including whipper-snippers and hedge trimmers.