Lithium Rechargeable Pouch Cells
The Hidden secret

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Why Lithium Rechargeables

- High Energy and power density
- High voltage par cell
- Long cycle and calendar life
- High charge/discharge efficiency
- Attractive cost per WH
- Many manufacturers
- Different shapes and sizes

… 24 years later the Li-Ion technology is still under development

- Strong demand for consumer electronics and Automotive Markets
- Fastest growing battery system
- Billions of cells manufacture every day

Lithium Rechargeable Systems

1. Lithium Cobalt Oxide (LCO cathode)
2. Lithium Manganese Oxide spinal (LMO cathode)
3. Lithium Nickel Cobalt Manganese oxide (NCM cathode)
4. Lithium Nickel Cobalt Aluminum (NCA cathode)
5. Lithium Iron Phosphate (LPF cathode)

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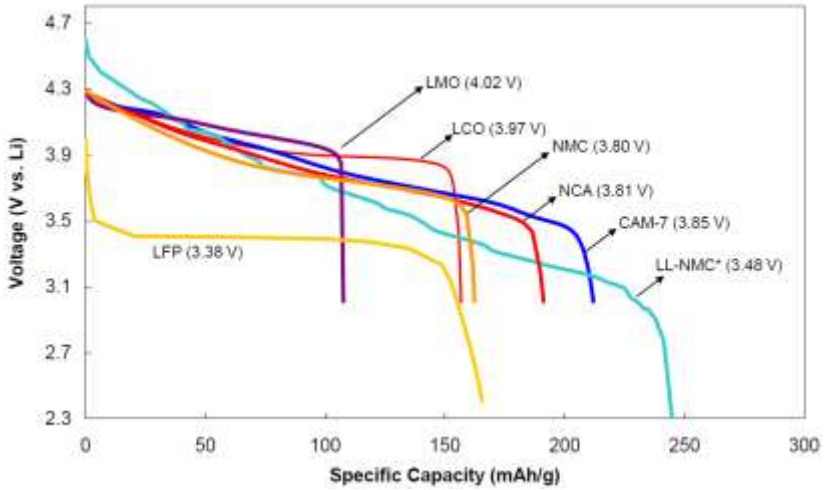
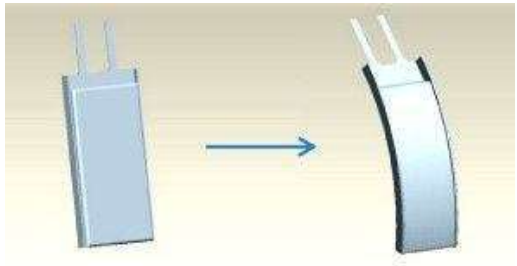
1. Lithium Sulfur (Li-S, Sulfur cathode – Li Metal Anode)
2. Lithium Metal Solid Electrolyte (Li Metal Anode)
3. Lithium Titanate (LTO anode)
4. Lithium with Nano-Structure Silicon (Li-Si Anode)



Lithium Cells Packaging Types

Lithium Pouch
Prismatic
(Soft case)



Lithium Pouch
Curved
(Soft case)

Implantable
Special Shape
Hermetic
(Hard case)

Gas tight plastic
case

New

Lithium Pouch
Cylindrical
(Soft case)

Cable battery

Lithium
Conventional
Prismatic
(Hard case)

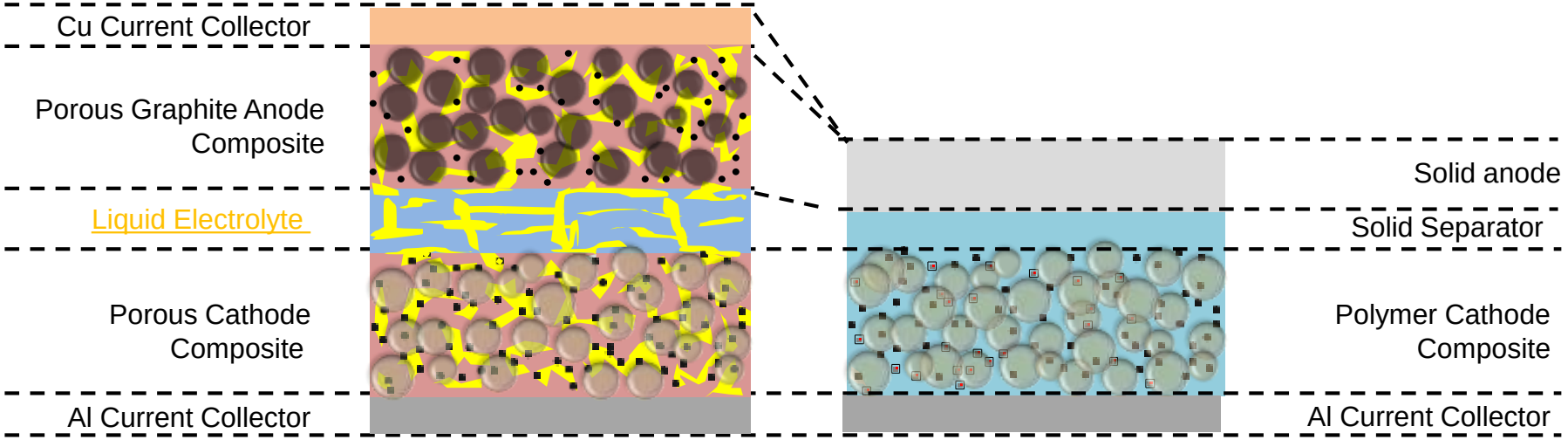
Lithium
Conventional
Cylindrical
(Hard case)

Lithium
Conventional
Button
(Hard case)

Lithium Polymer Pouch Cell History

1. 1998 – Sony launched a mass production of Li-Polymer cells using Aluminum film as pouch case
2. Conductive foil tabs are welded to the electrodes
3. Since then Lithium Pouch cells used for many applications and demand is strongly growing

Main Electrolyte Types

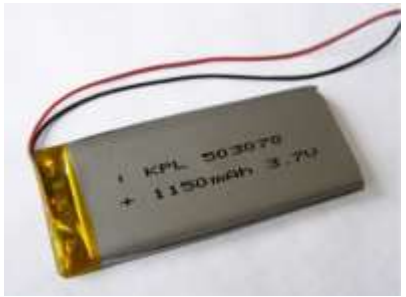


Conventional Lithium rechargeable cells (Stainless Steel or Aluminum hard cases)

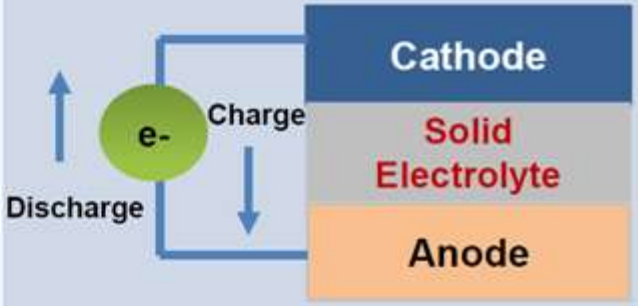
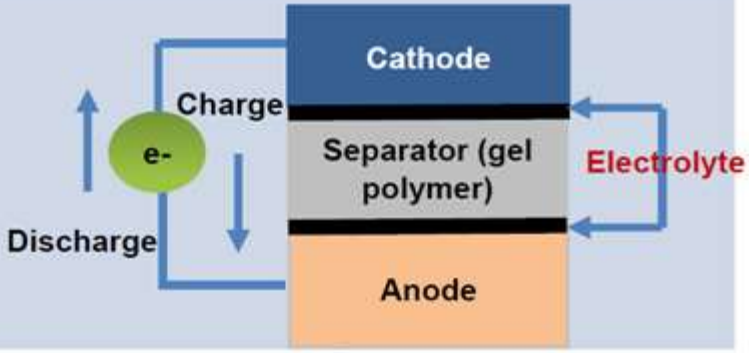
Organic Liquid Electrolytes

Lithium Polymer rechargeable pouch soft cases (Aluminum foils soft case)

Gel Electrolyte



Solid Electrolyte Under Development

	All Solid State lithium batteries		Traditional lithium ion batteries	
Structure				
Electrolyte	Inorganic materials(Sulfide, Oxide...etc.)	High polymers (PEO..etc.)	Organic electrolyte(PC,EC,DEC..Li PF6)	Polymer organic electrolyte
	• High safety • High energy density • Simply assemble • Long storage life • High temperature resistance	• High safety • Winding • Flexible processing	Applied to 3C products (Energy storage)	Applied to the small electronic products
Disadvantages	• Low power density • High cost	• Low power density • High cost • Low thermal adaptability	Volatility and fire at high temperature due to the organic electrolyte	

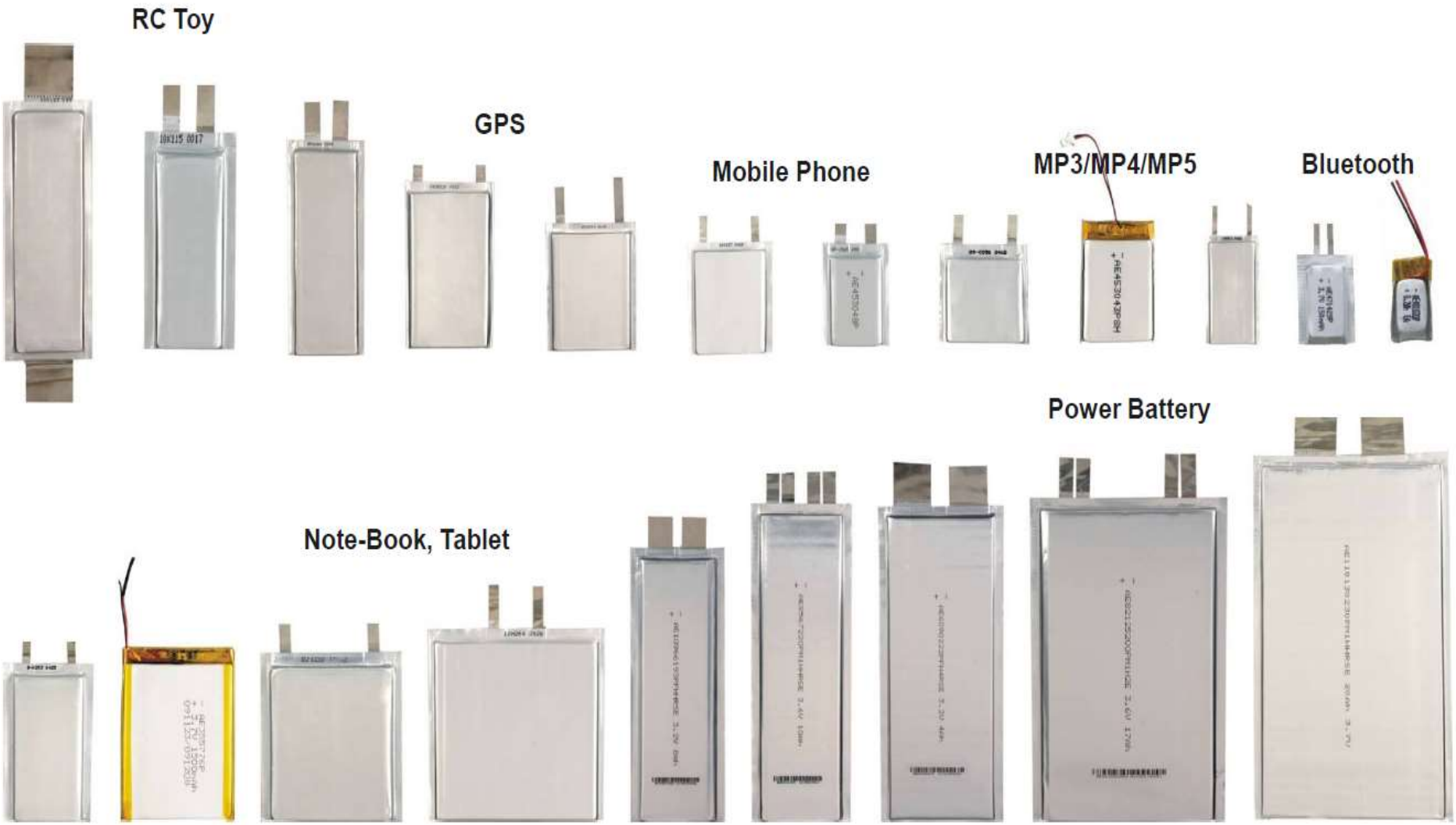
Pouch Cells – Advantages

1. **Thin format – efficient packaging**
2. **Employ flexible welded aluminum case – Reduced weight**
3. **High volume density (Prismatic)**
4. **Good thermal characteristics – High surface area**
5. **Flexible sizes – No standardized pouch cells exist – each manufacturer designs it owns – NRE for a new size mold is in a cost of 1-2$K**

Pouch Cells – Limitations

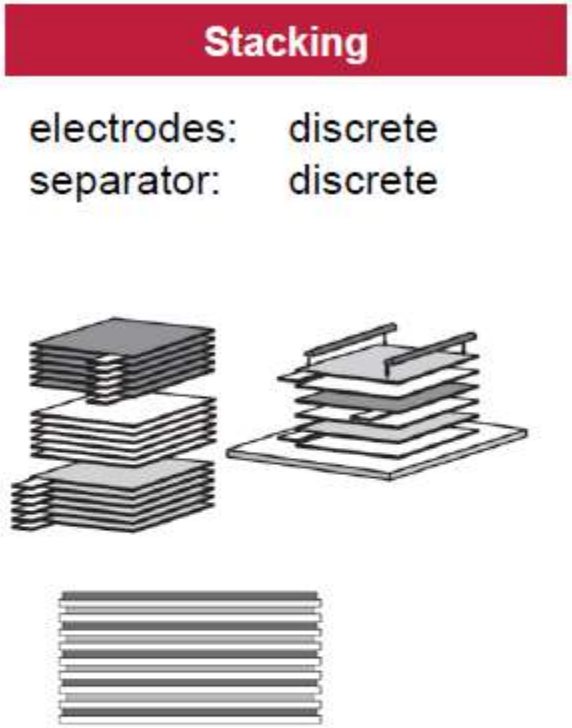
1. Lower energy and power density in compare to hard case cells
2. Gassing (Swelling, “Ballooning”) Problems
3. Higher risk for leaks when use liquid electrolyte
4. Needed an extra expansion space and some mechanical support in the battery compartment (expand/compress while charging/discharging)
5. Reduced cycle life in compare to hard case cells
6. Expansive to manufacture (Semi-automatic lines)
7. Poor robustness in compare to hard case cells

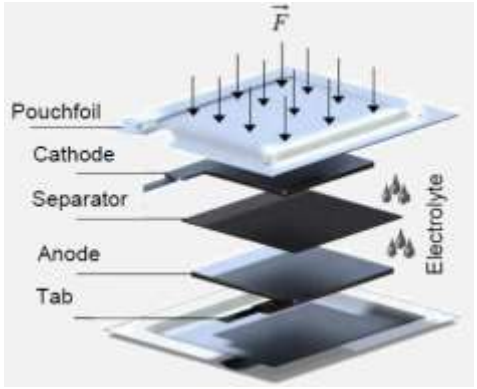
Lithium Pouch Size Versatility

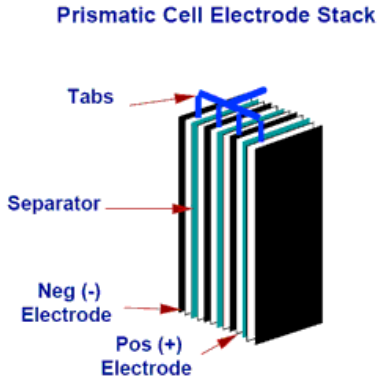


Pouch Flat Plates Type (Stacking)

- **Electrodes are made in form of flat plates suspended in the electrolyte which is held in suitable container.**
- **Can be scaled up to very large sizes, larger plates providing for higher currents and larger containers allowing high capacities.**

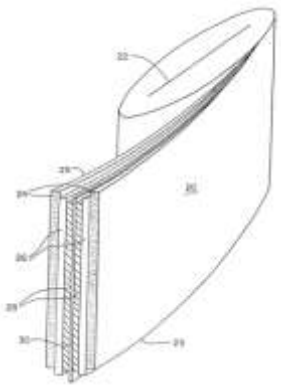


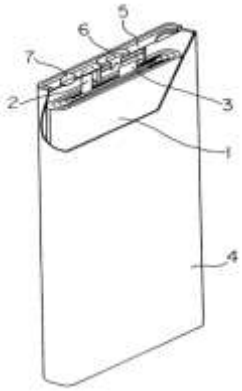


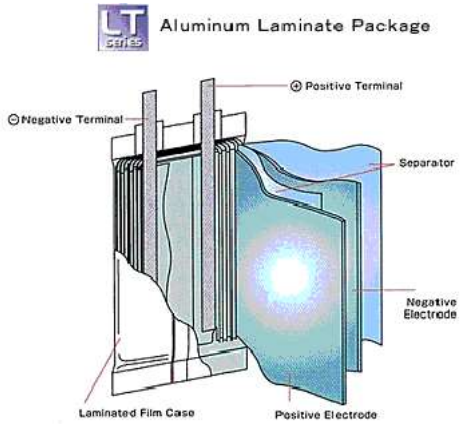


Pouch Flat Wound Type

- **High speed manufacturing via automatic winders.**
- **Good thermal characteristics.**
- **High energy density in Multi-cell design.**

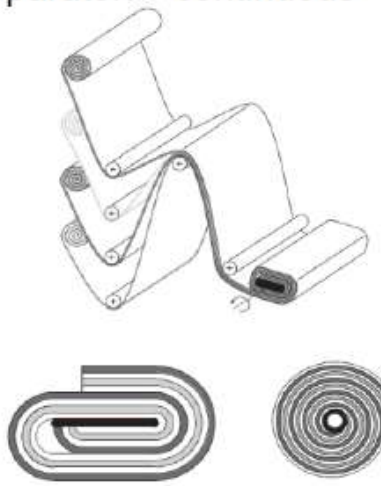






Winding

electrodes: continuous
separator: continuous



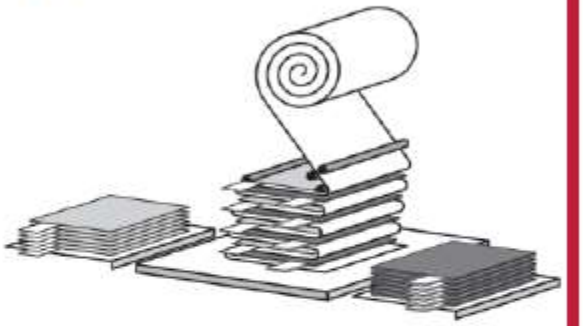
⊕ high productivity
⊕ material feeding
⊖ bending of electrodes
⊖ complex machinery

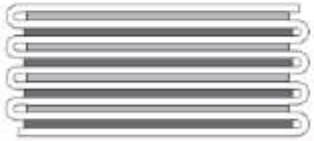
Pouch Z-Folding Type

Electrode Packaging Process via Z-Folding

Z-Folding

electrodes: discrete
separator: continuous





- ⊕ separator feeding
- ⊕ in-line sorting of electrodes
- ⊙ cycle time
- ⊖ separator bending

New Cylindrical Lithium Pouch cells

Comparing the battery with different pack way.

Soft package

Customized design

Hard package

Standard design

EVE ENERGY VERY ENDURE

Pouch cells – The Hidden Secret

1. **Strong demand for thin consumer applications drive the pouch cell growing market**
2. **The need for longer run time force Consumer electronic OEM's to push the cell makers to increase cells energy and power densities**
3. **From business prospective The OEM's also push for lower cell cost**

As a result, cell makers manufacture pouch cell with liquid organic electrolyte instead of gel polymer electrolyte!!!

What so Bad in Liquid Electrolyte for Pouch cells?

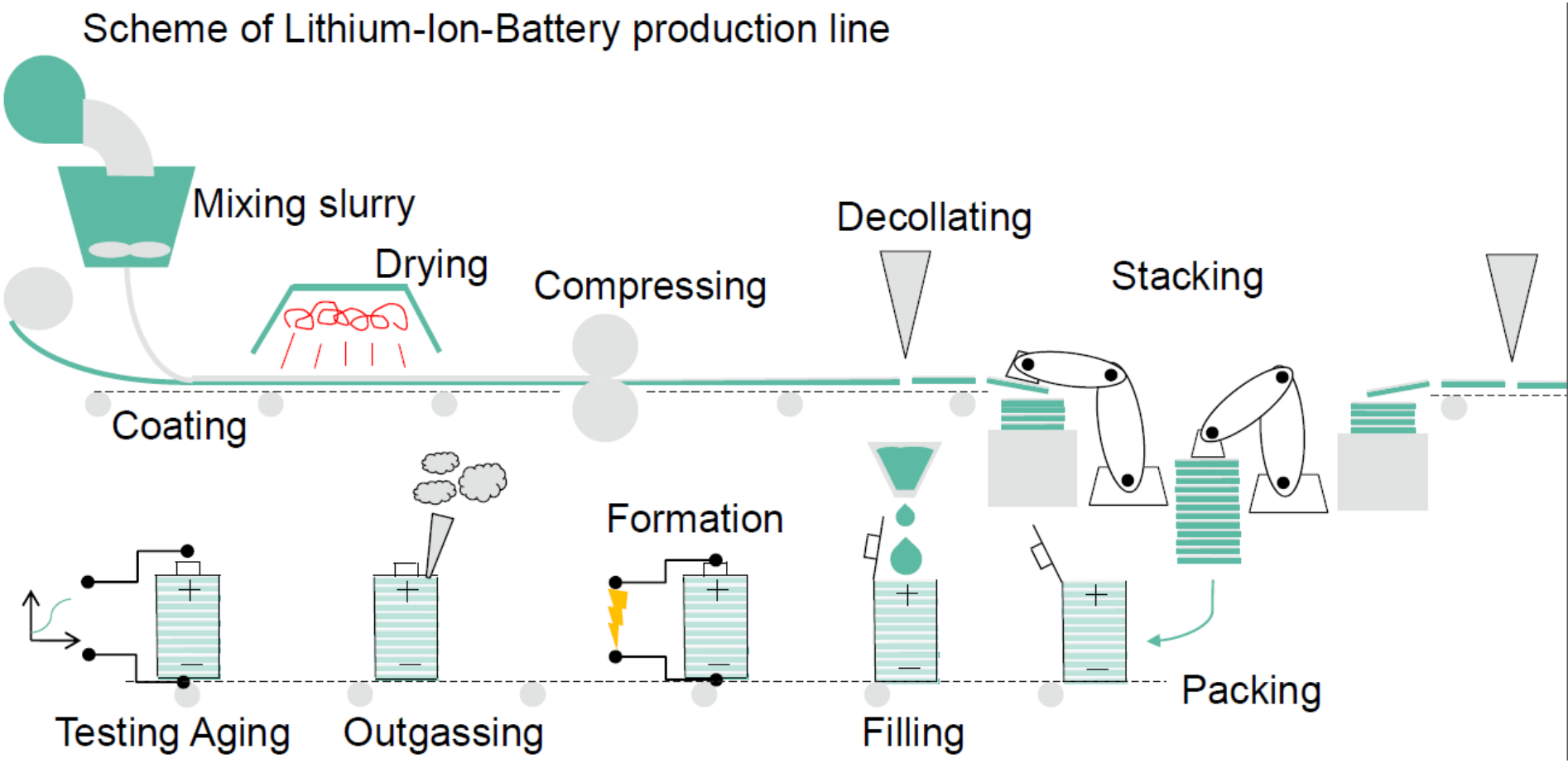
1. Sever swelling (gassing) concerns in compare to pouch polymer cells
2. The pressure created can crack the battery cover and in some cases damage the host
3. High risk of electrolyte leaks - Electrolyte is corrosive and when is leaking damage the battery and the application
4. High risk of fires - organic electrolyte
5. Leaking electrolyte is a danger materials in case it touch our skin or we breath it when it evaporates

Root Cause for the Pouch Cells Gassing

1. High temperature operation or storage (> 60°C)
2. Low state of voltage during discharge (< 3v)
3. High state of voltage during charge (>4.25 v)
4. Improper drying process for anode and cathode
5. Improper manufacturing – Dry condition should be kept during production and hydrogen generated after first charge should be evacuate properly from the cell

Form a hydrogen gas release inside the cell !!!

Pouch Cell Production



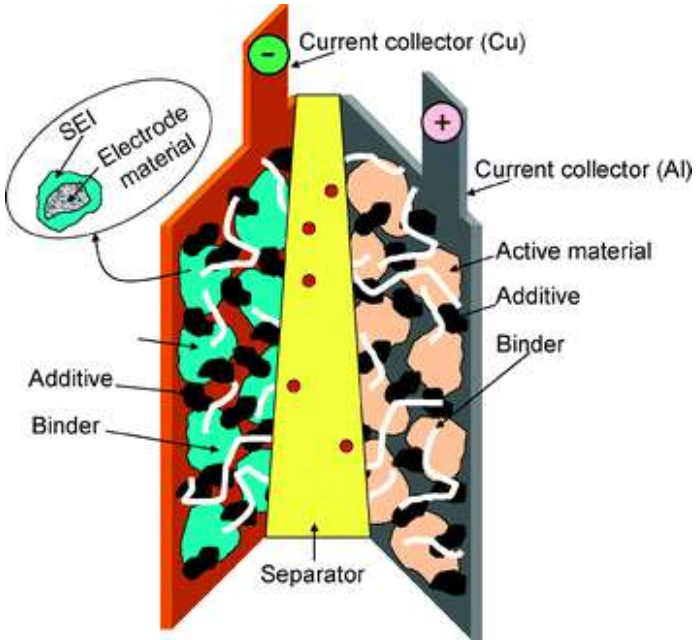
Source: Fraunhofer

Pouch Cells – The First Charge

1. At the first cycle the solid electrolyte interface is forming

2. Process parameters like current, pressure, temperature affect the SEI formation

3. The SEI has a strong impact on cell internal resistance, cycle life and calendar life



Electrode Drying

1. **Dry electrode will insure minimum cell gassing.**
2. **The process done in drying chamber with air humidity of approx. 0.5%.**

Automatic Lithium Battery Production Dehumidifier , Dry Air Supplying System from China

Outgassing

1. At the end of production the cell capacity is zero
2. On the first cell charge most of the electrolytes are gassed
3. There is a need to evacuate the gas prior to final cell sealing

The DSU 260, Pouch degassing machine is designed for production of Lithium ion cells.
Sealing is performed under vacuum to remove gases developed by lithium cell reactions during formation cycle.
Degas and pouch trim are two separate modules for better maintenance and process control.
Equipment is provided with wheels for an easier positioning and relocation inside laboratory or dry room.

Aging

1. After evacuation of hydrogen from the first charge the cells complete forming and start aging process at high temperature for several days
2. At the end of aging there is a need to repeat evacuating the hydrogen generated inside the cell

Modular system for pouch cell aging after formation.
PLC controlled cycle with different temperature settings (adjustable on HMI) , cell data tracking.

Leaking Test after Cell Sealing

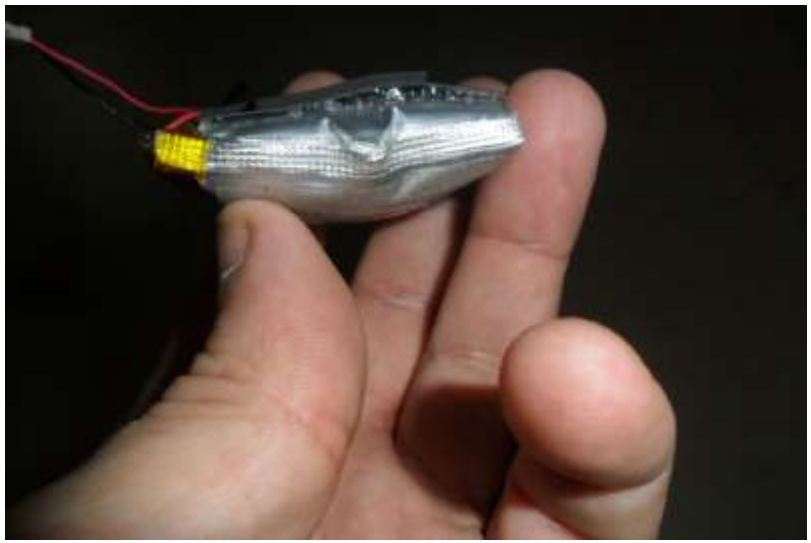
1. Cells should be hermetically sealed and leakage proof
2. After completing sealing process the cells stayed 2 hours at 5 Bar Helium chamber
3. In case of leaked cell the cell will be ballooned with Helium
4. The ballooned cells are rejected

TiTAN TEST
by LACO TECHNOLOGIES

LEAK DETECTOR
VACUUM CHAMBERS

Li-Ion Pouch Ballooned Cells - Investigation Case

1. A customer that had to recall 30,000 of his products because of Li-Po ballooning.
2. The swelling cells broke the application case.
3. Deep investigation figure out that the discharge cut off voltage of the application is 2.5v instead of 3v – along charge/discharge cycles there was a strong hydrogen release.



Summary

- **Strong demand for high energy, power density and cost reduction in thin cell format, drive the pouch cell growing market**

- **Pouch cell makers use liquid electrolyte instead of gel polymer as a way to meet the customers demands**

- **Pouch cells with liquid electrolyte tend to leak and safer from more gassing problems in compare to gel polymer pouch cells**

Summary

- **Liquid organic electrolyte generate higher concern for fires in case of safety events**
- **The customers are not always aware to the difference between pouch cells with liquid electrolyte and gel polymer**
- **Manufacturers should find way to strength the pouch packaging to be more leak resistance**
- **Manufacturers need to develop processes to reduce the gassing problem to minimum**

Thank You for Your Attention

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