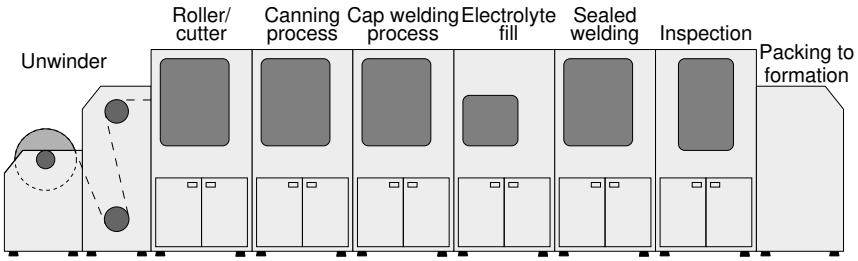
Cell assembly

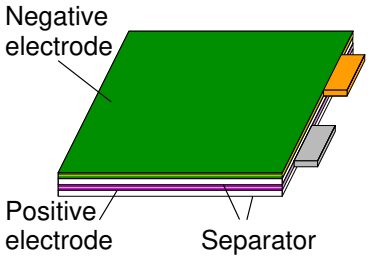
- Comprises building electrode subassembly, packaging, filling with electrolyte, sealing and welding, inspection



- Some details vary depending on whether making pouch or cylindrical/prismatic cell

Stacked electrode structure

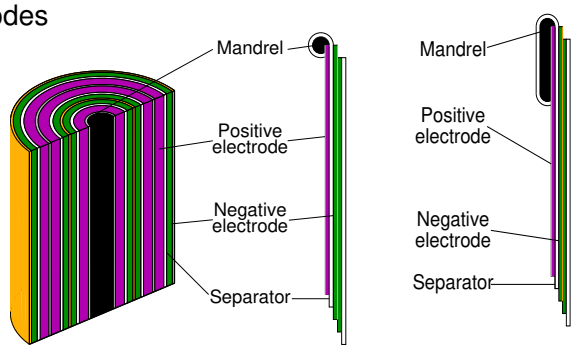
- Pouch/prismatic cells often used for high-capacity battery applications to optimize use of space
- Pouch designs use stacked electrode structure in which negative- and positive-electrode foils are cut into individual electrode plates that are stacked alternately and kept apart by the separator
- Separator may be cut to the same size as electrodes but more often is a long strip wound zig-zag between alternate electrodes in the stack



- All negative-electrode tabs are welded in parallel and to the cell's negative terminal; all positive-electrode tabs are welded in parallel and to the cell's positive terminal

Cylindrical and prismatic electrode structure

- For cylindrical cells, negative- and positive-electrode foils are cut into two long strips and wound on a cylindrical mandrel together with separator to hold electrodes apart, to form a jelly roll
- Most prismatic cells are constructed similarly, by winding electrodes on a flat mandrel
- Tab(s) connect electrodes to terminals (multiple tabs for high-current cells)

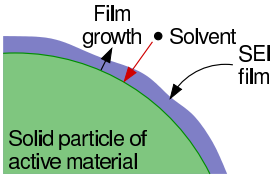


Final steps: electrolyte fill

- Safety devices connected; subassembly inserted into package
- Package sealed via laser welding or heating, leaving opening
- Cell is filled with electrolyte through opening, then sealed
  - Must be done in a dry room as electrolyte reacts with water
  - Moisture will cause the electrolyte to decompose with the emission of toxic gases
  - Lithium hexafluorophosphate ($LiPF_6$) for instance, one of the most commonly used electrolyte salts, reacts with water forming toxic hydrofluoric acid (HF)
- Finally, cell is given an ID with a label or by printing serial number on case
- Cell is now ready for its first charge…

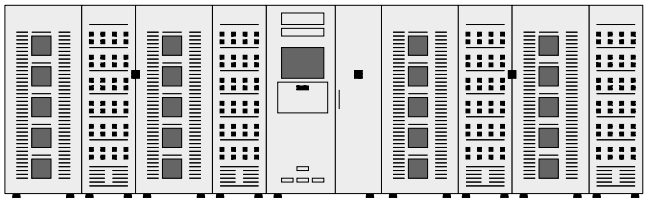
A critical issue: SEI layer

- Lithiated graphite reacts with solvent in electrolyte, forming solid–electrolyte interphase (SEI) film layer on particles
- SEI consumes lithium (capacity loss) and impedes ionic conductivity (power loss) but also stabilizes graphite
- Lithium-ion cells are assembled in fully-discharged state (0 V, all lithium is in positive electrode): no SEI yet
- Must be put through at least one precisely controlled charge
- During first charge, graphite is lithiated, most of SEI is formed, so this first charge is termed the formation process



The formation process

- SEI should be formed slowly for thin uniform layer
- Cell may also need gentle cycling to stabilize SEI layer
- If badly done, can cause permanent capacity loss and a rise in internal resistance
- Formation processes are proprietary (not simply normal CC/CV charging), may take several days or even weeks, include floating or resting at different temperatures



Acceptance testing

- During formation, cell-performance data are gathered and recorded for quality analysis
  - High self-discharge (voltage measured after rest) points to manufacturing defect
  - Mismatched capacity or impedances indicate processes not under control
  - In-tolerance data assist in cell matching or “binning”
- Desire manufacturing defects be identified by formation, not in customer products
- To avoid low yield, must enforce tight tolerances, strict process controls
  - Contamination, physical damage, burrs on the electrodes very dangerous since can cause separator penetration, internal short circuits
  - Cells normally manufactured in clean-room conditions to avoid contamination

Summary

- Cell construction comprises building electrode subassembly, packaging, electrolyte fill, sealing and welding, inspection
- After construction, cell undergoes formation cycle to grow thin SEI layer
- By-product of formation cycle is data set that enables acceptance testing, binning
- Finally, cells are packaged and shipped (usually at a mid-range SOC)