



## How are a lithium-ion cell's electrodes fabricated?

- Knowing how cells are made aids understanding cell operation
- Cells are manufactured in different form factors
  - Cylindrical cells are... err... cylindrical (round "jelly roll")
  - Prismatic cells are... prismatic (flat "jelly roll")
  - Pouch cells are also flat, but comprise stacked plates



Cylindrical cells



Prismatic cells

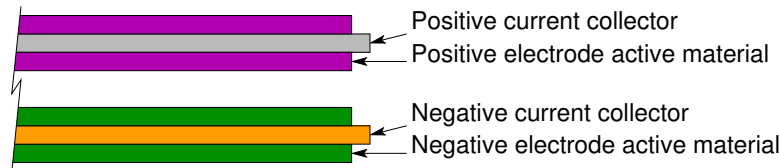


Pouch cells



## Electrode structure

- Electrodes in lithium-ion cells are of similar form and are made by similar processes on similar or identical equipment
- The active electrode materials are coated on both sides of metallic foils which act as the current collectors conducting the current in to and out of the cell

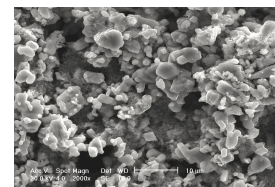
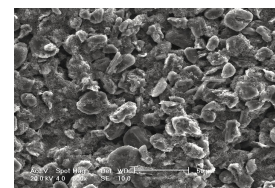


- Colors are for illustration: actual materials are black powders indistinguishable from each other visually



## Electrode materials

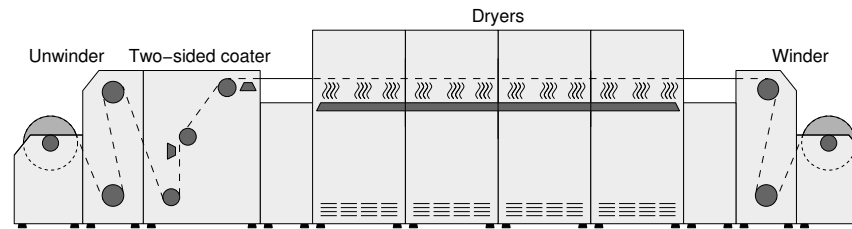
- Negative-electrode material is usually a form of graphite
- Positive-electrode material is usually a lithium metal oxide
  - Contamination between materials will ruin cell: negative and positive electrodes processed in different rooms
- Particle size and shape are important
  - Must be small to achieve the large electrode material effective surface area needed for high-current cells
  - Desire smooth spherical shapes since sharp edges susceptible to higher electrical stress and decomposition of SEI layer, which can lead to premature aging and possible thermal runaway when the cells are in use





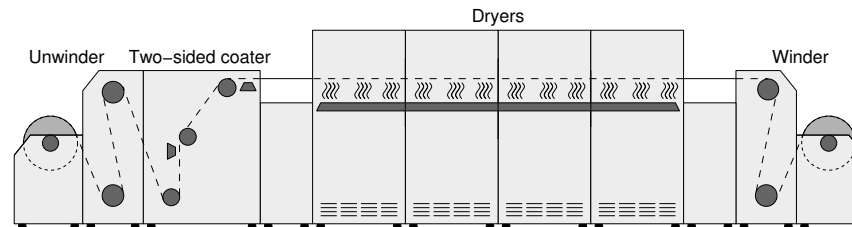
## Electrode coating (1)

- Current-collector foils delivered on large reels,  $\approx 0.5$  m wide
  - Cu for negative and Al for positive current collector
- Reels mounted directly on coating machines where the foil is unreeled as it is fed into machine through precision rollers



## Electrode coating (2)

- First stage is to mix electrode materials with conductive binder to form slurry that is spread on foil surface

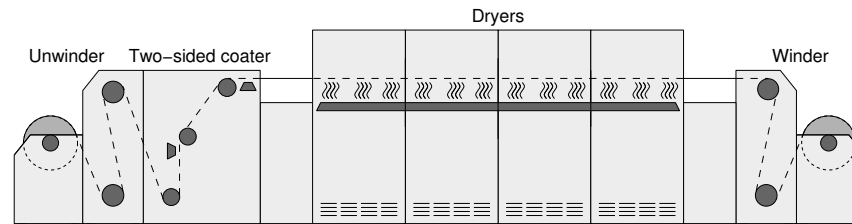


- A knife edge is located just above the foil and the thickness of the electrode coating is controlled by adjusting the gap between the knife edge and the foil.
  - Thicknesses chosen so energy storage of negative/positive electrodes match



## Electrode coating (3)

- From the coater, coated foil is fed directly into long drying oven to bake electrode material onto the foil

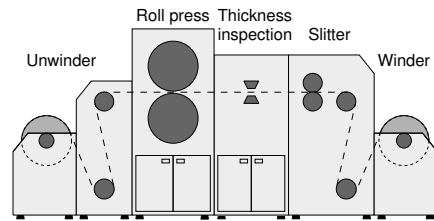


- As coated foil exits oven, it is re-reeled



## Electrode calendering

- Coated foils subsequently fed into a calendering (pressing) and slitting machine
- Compresses electrode, compacting spaces between particles, pressing out porosity, ensuring electronic contact between particles
- Slitting cuts the foil into narrower strips of the desired width (later they are cut to length)
- Any burrs on the edges of the foil strips could give rise to internal short circuits in the cells so the slitting machine must be very precisely manufactured and maintained



## Summary

- Have seen first stages of cell construction
  - Metal foils are unrolled
  - Slurry of electrode solid materials deposited on foils
  - Dryers evaporate solvents
  - Calendering produces desired porosity, ensures contact of active materials
  - Foils re-reeled in preparation for next steps



## Credits

- SEM images of lithium-ion electrodes on slide 3 courtesy Sangwoo Han, used with permission