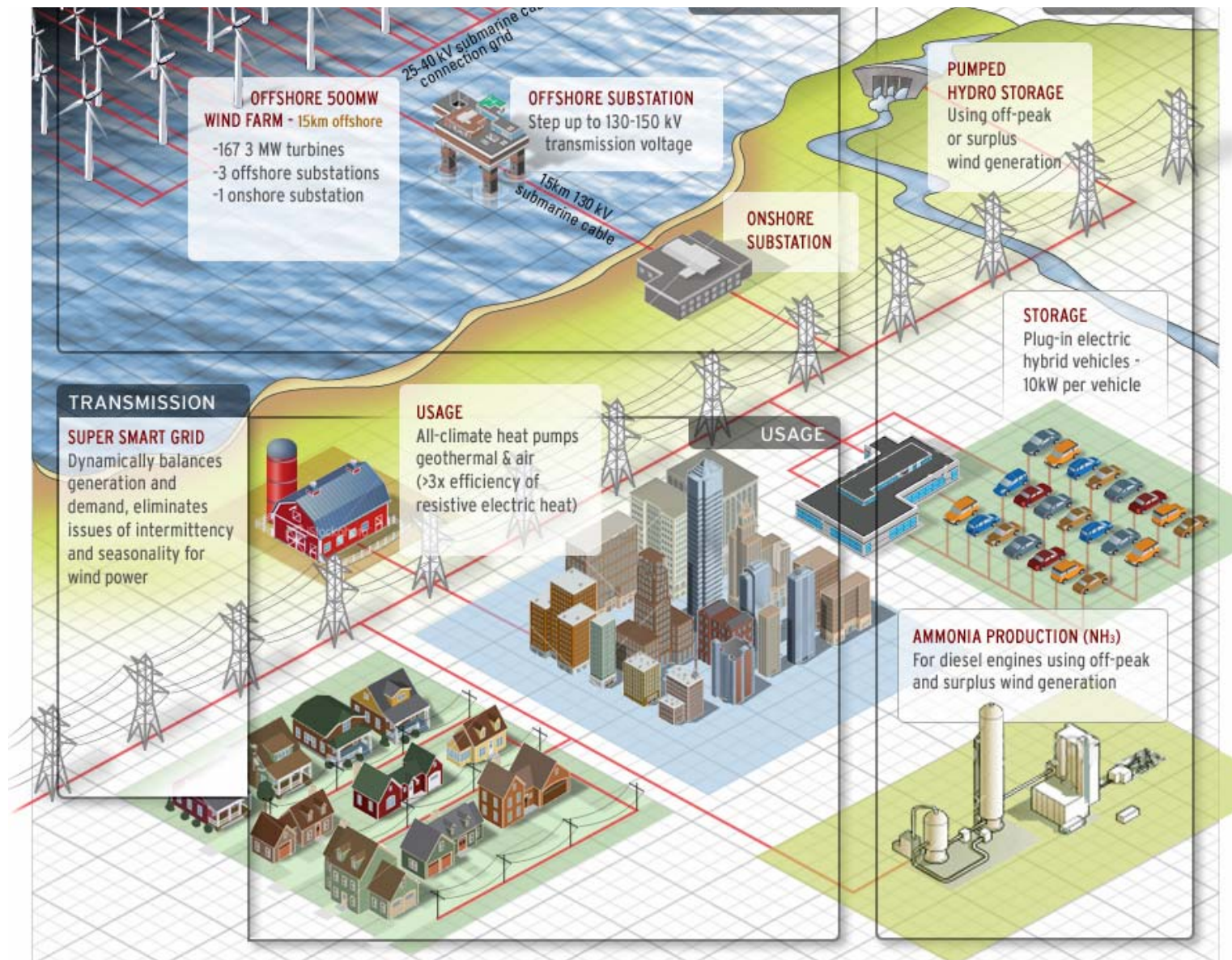


Nickel and Li-ion Batteries

Bridging the gap between EV and grid scale storage

- Nickel-(Cd, Iron, MH, H₂)
- Li-ion (Li_xCO₂, LiMnO₂, Li_xMn₂O₄, Li_xNiO₂, Li_xV₂O₅, Li_xPFeO₄...)

Grid scale storage with EV



Grid scale storage with EV

- A possible solution to partially achieve grid scale storage with high cost Ni and Li-ion batteries
- Big questions exist:
 - 10kW EV battery powerful enough to power your home?
 - The grid smart (agile and efficient) enough to dispatch electricity around?

Ni-Cd

Anode (-)



Cathode (+)



Ni-Fe

Anode (-)



Ni-MH

Anode (-)

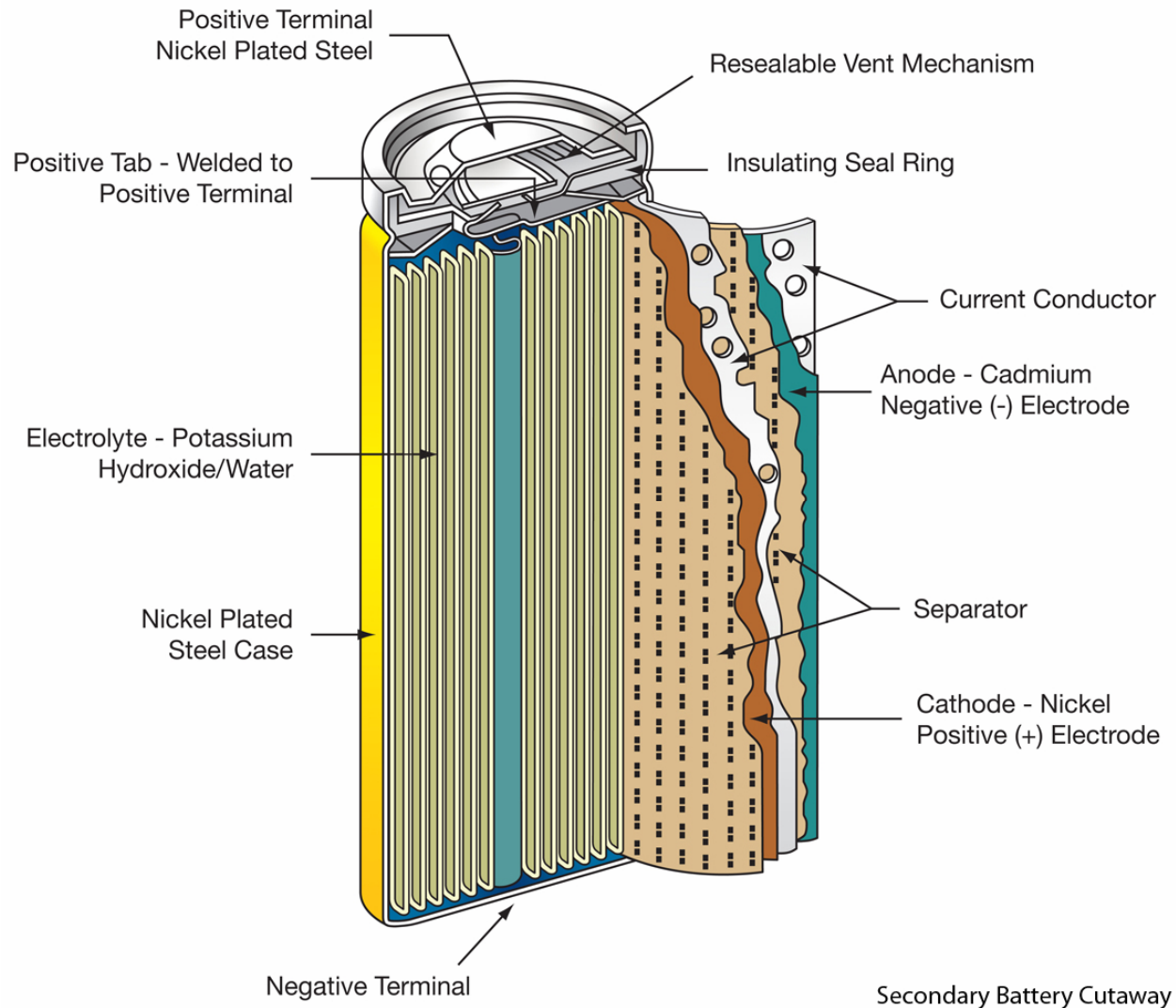


Ni-H₂

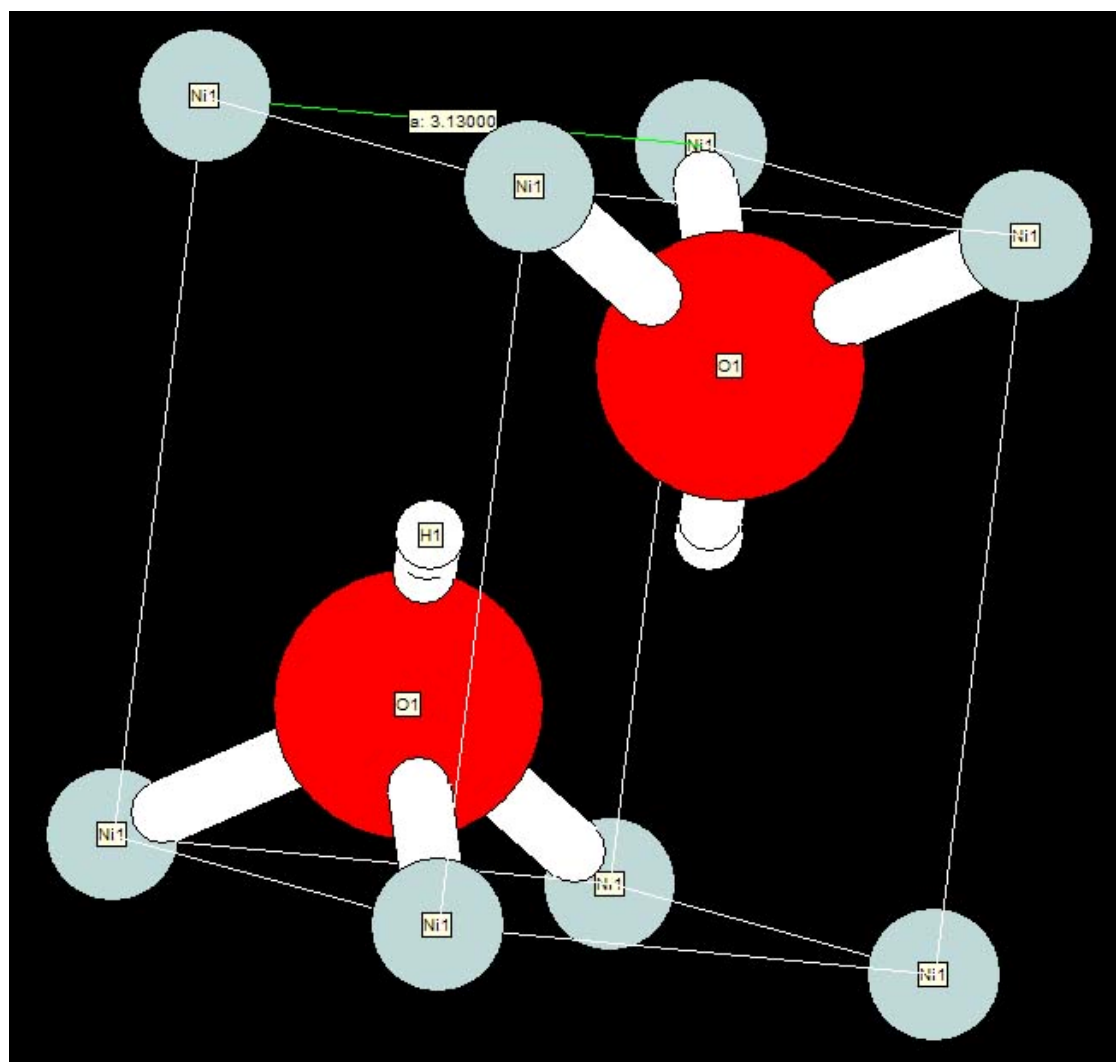
Anode (-)



Ni-Cd

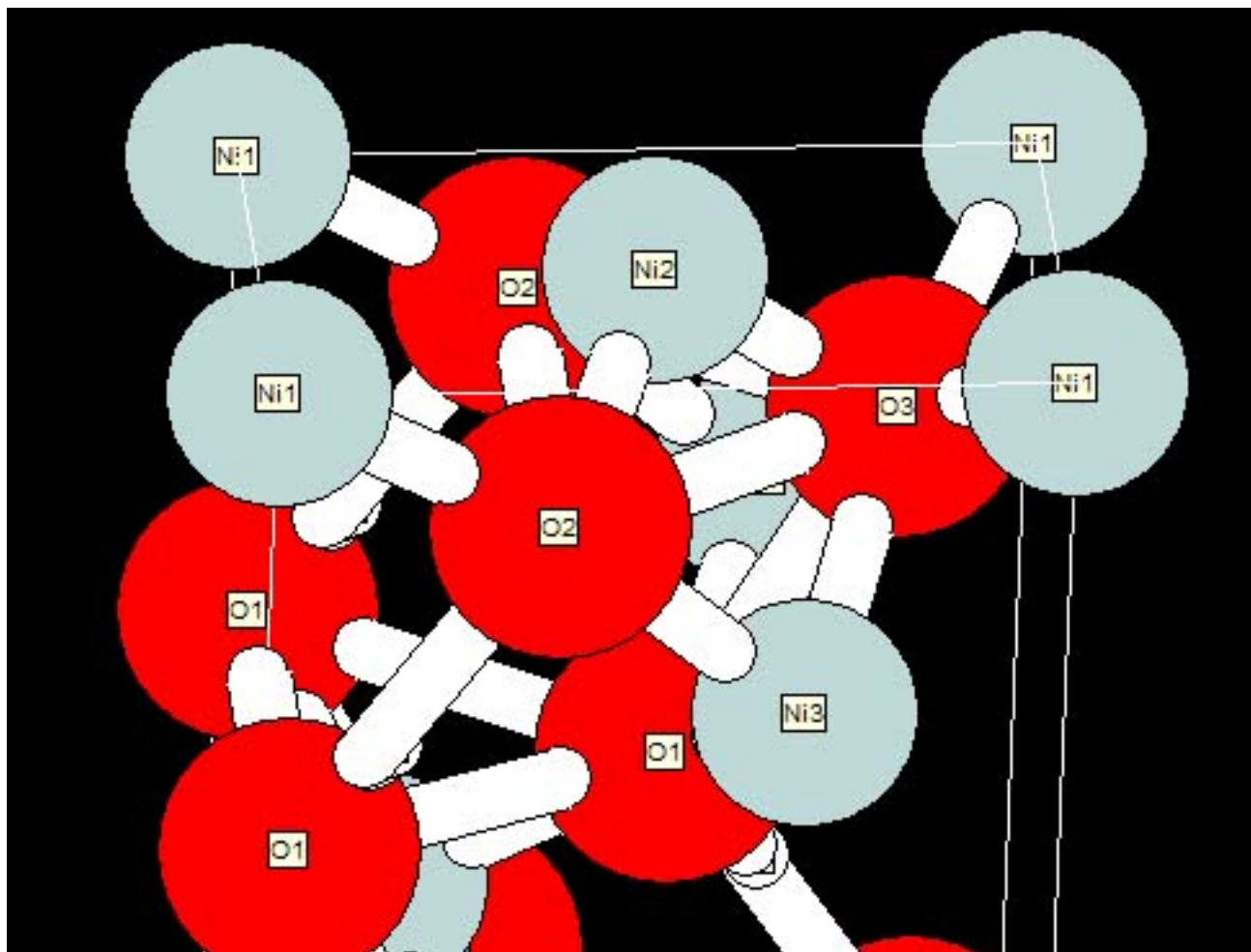


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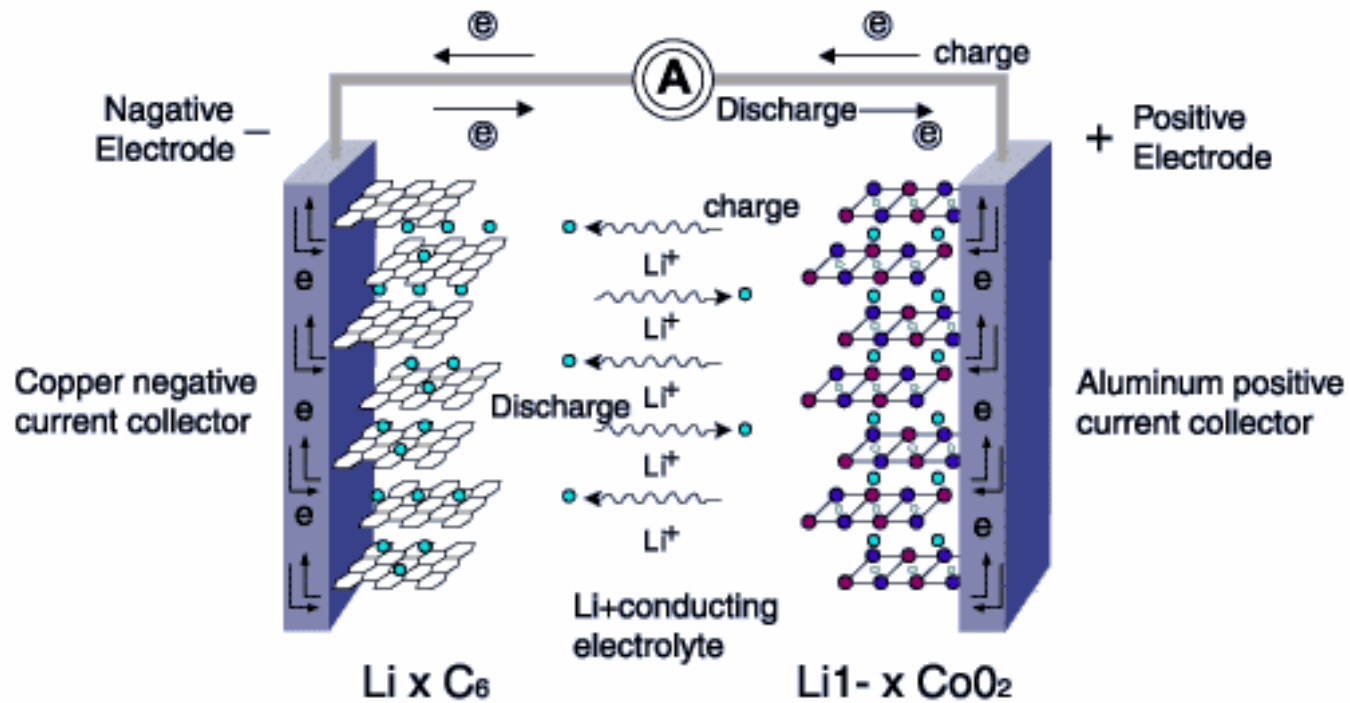
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NiOOH



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Li-ion



- O (Oxygen)
- ⊙ Co (Cobalt)
- C (Carbon)
- Li^+ (Li-ion)

The famous
Li-ion
Rocking Chair



Li-ion

Anode: Essentially Li intercalated graphite

Cathode: many types

Lithium transition metal oxides

Li_xCoO_2

Li_xNiO_2

LiMnO_2

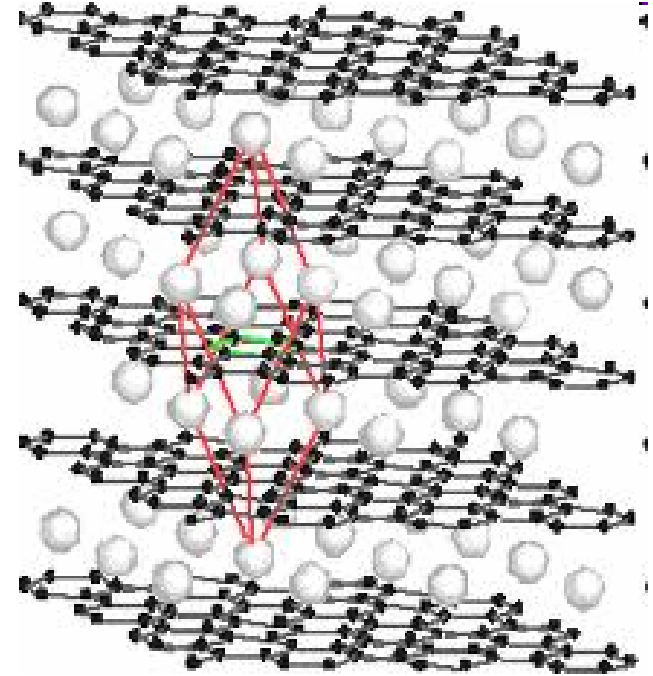
$\text{Li}_x\text{Mn}_2\text{O}_4$

Li_xNiO_2

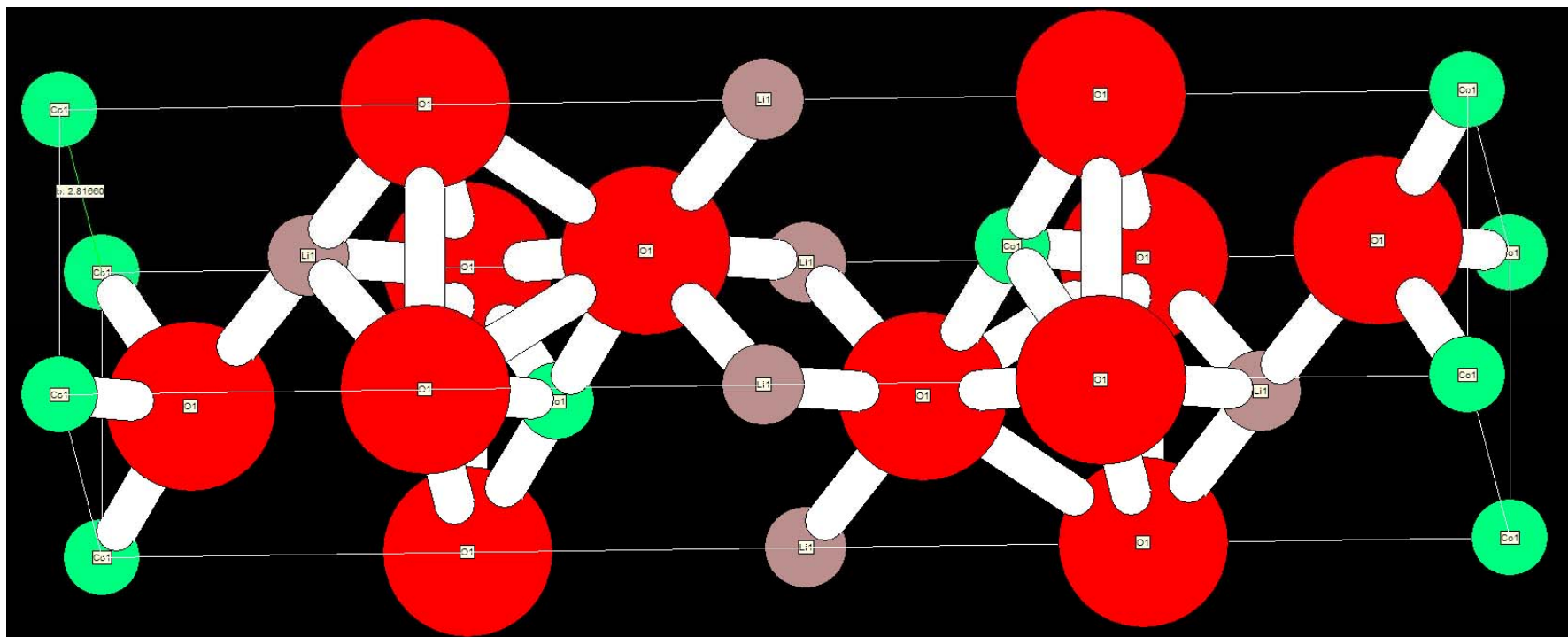
$\text{Li}_x\text{V}_2\text{O}_5$

$\text{Li}_x\text{PFeO}_4...$

Sulfide (pyrite, etc.)

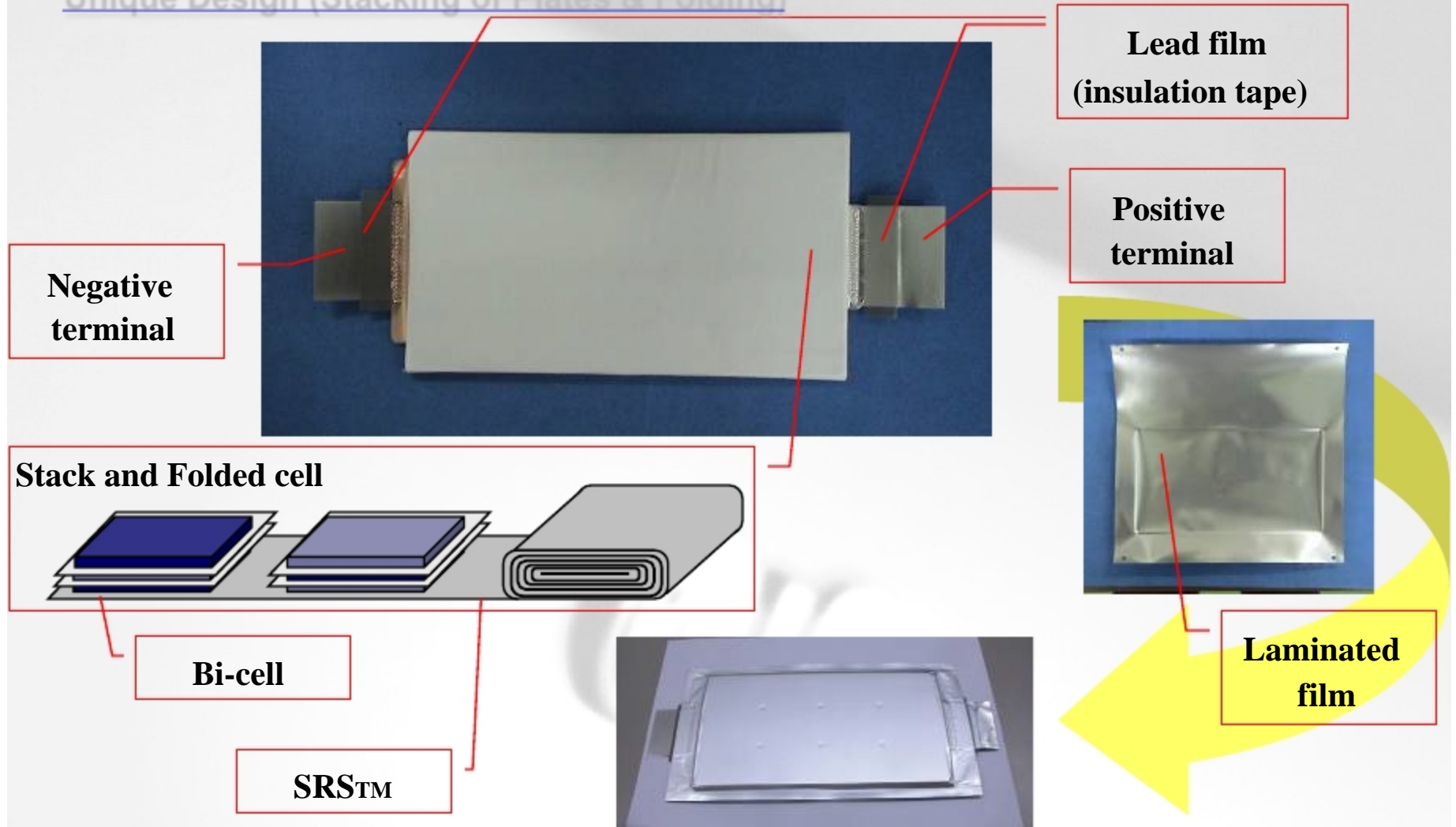


A Typical Cathode



Li-ion: Example Structures

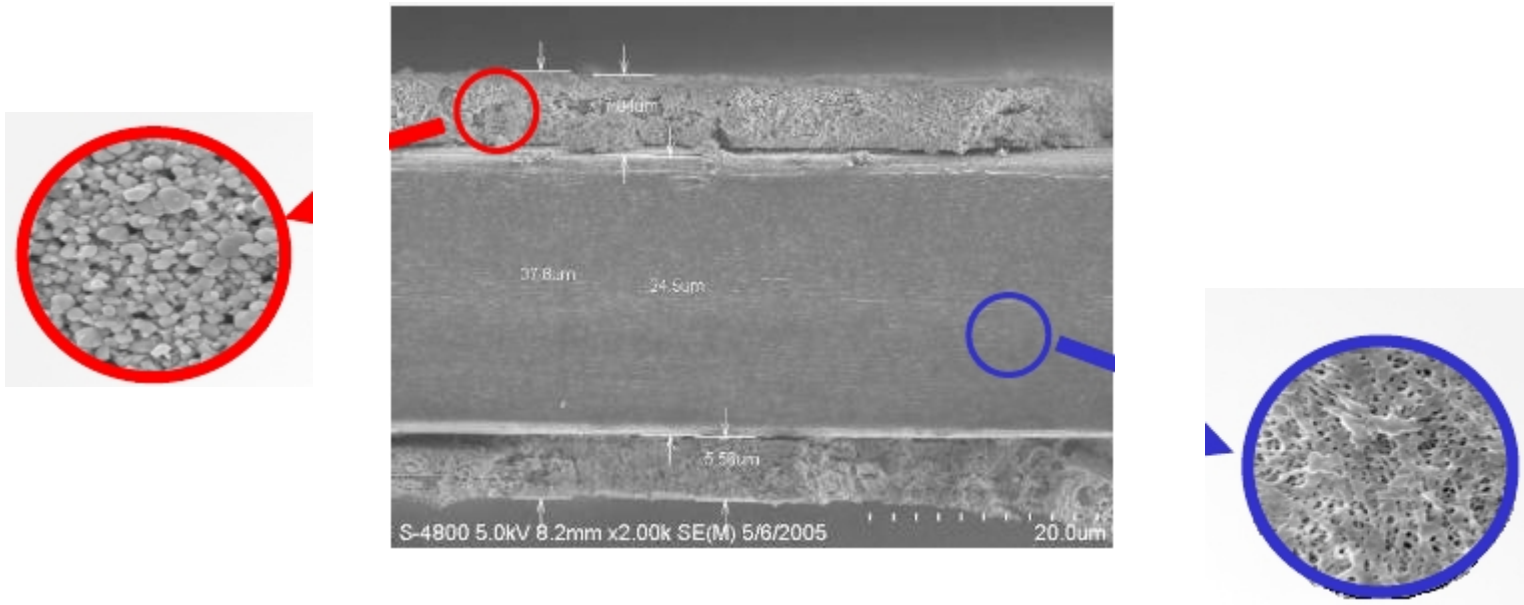
• Unique Design (Stacking of Plates & Folding)



Li-ion: Example Structures

Safety Reinforcing Separator (SRS™)

- By preventing internal short circuit
- By improved thermal and mechanical strength



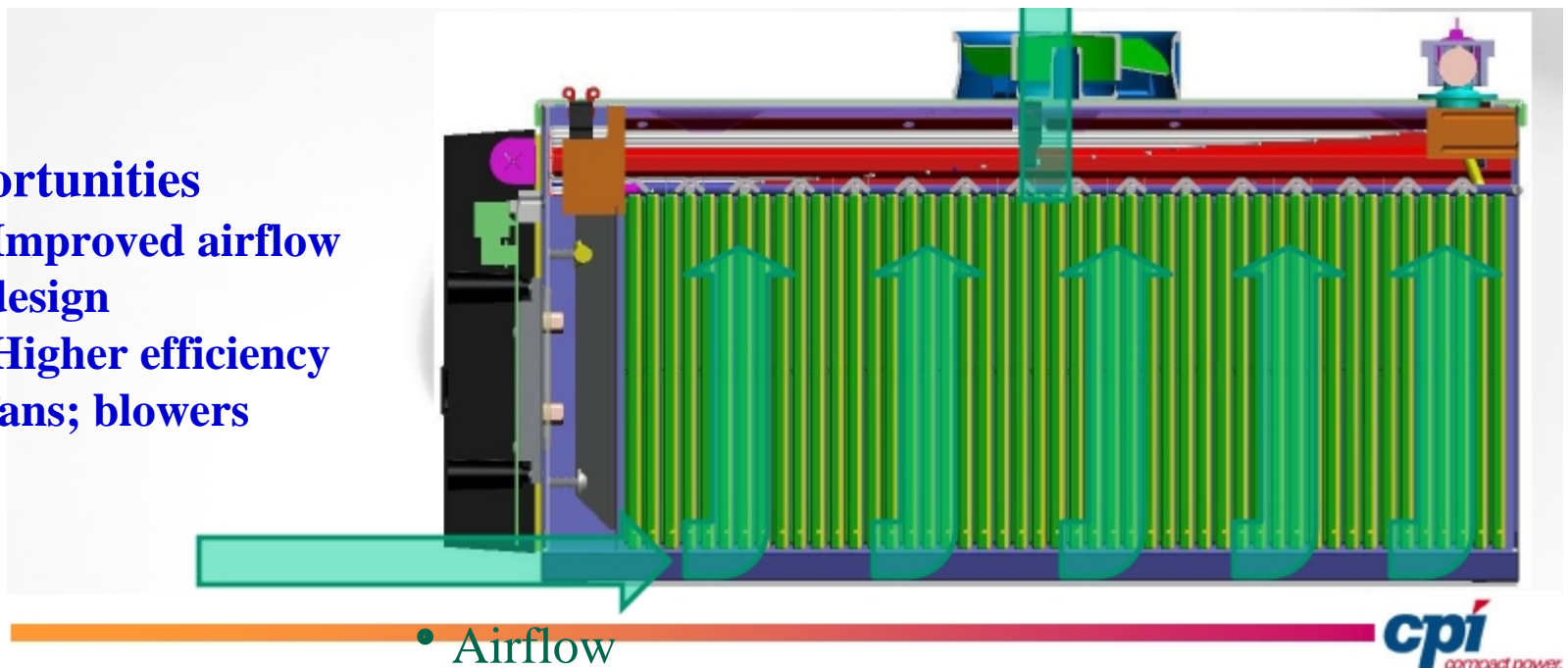
- Has significantly higher puncture strength than conventional separator

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Thermal Management in Plug-in Hybrid EV: Air Cooling

- **Attractive for most vehicle applications**
 - Low heat generation and even thermal distribution mean low cooling demand (once environmental heat is removed)
 - Cabin air generally cool enough to remove heat
 - Blower and duct work required.
 - 2 mm spacing between cells is generally sufficient

- **Opportunities**
 - Improved airflow design
 - Higher efficiency fans; blowers



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