

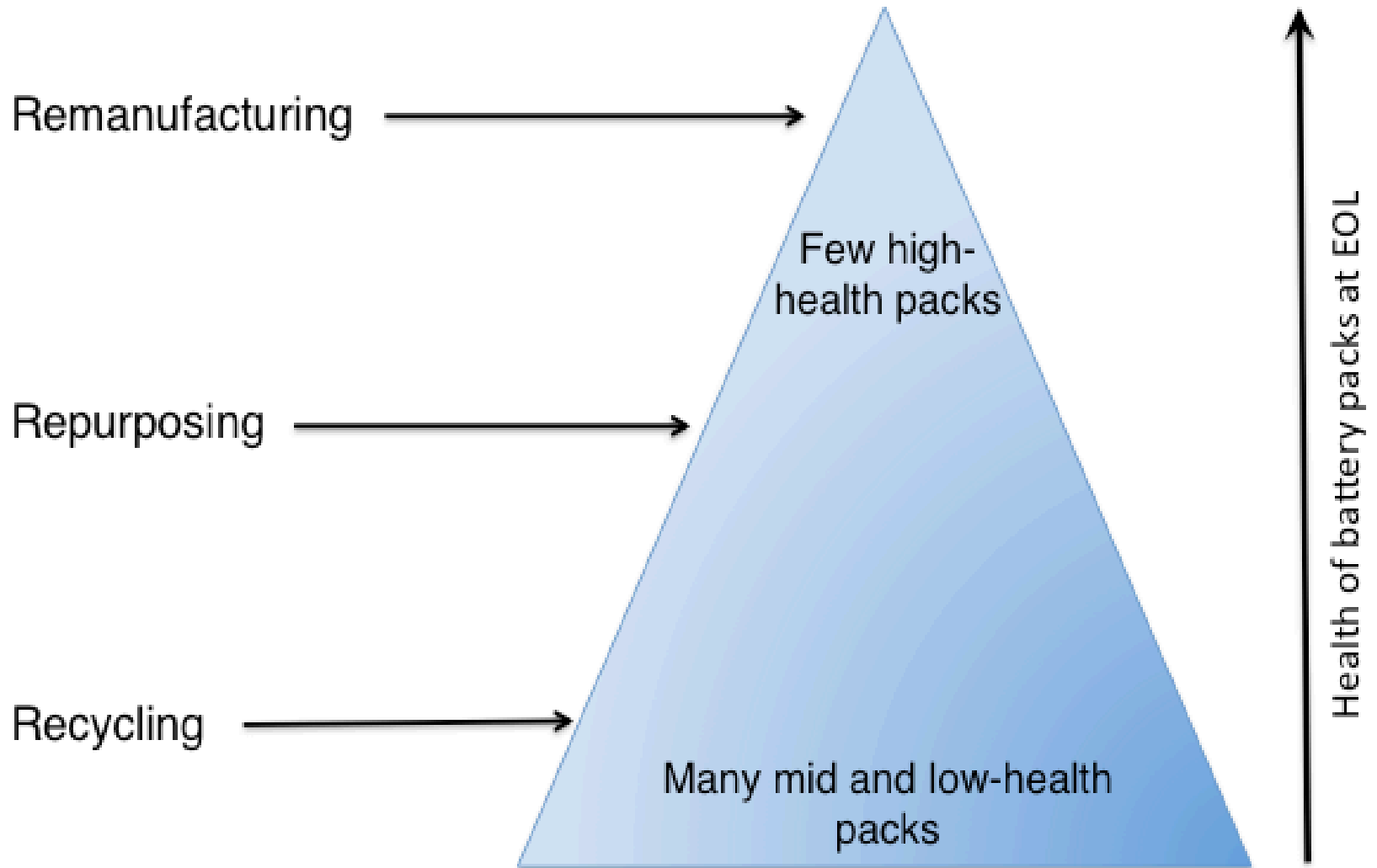
Challenges of Solid State Lithium Ion Battery Recycling

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Options of End of Life EV/HEV Batteries



Comparison between Lead-Acid and Li-Ion

	Lead-Acid	Li-Ion
Cathode	PbO ₂	LiMO ₂ or LiFePO ₄
Cathode foil/plate	Pb	Al
Anode	Pb	Graphite
Anode foil/plate	Pb	Cu
Electrolyte	H ₂ SO ₄	LiPF ₆ + Org. Solvent
Separator	PE or PVC w/Silica	PE/PP
Cell Case	PP	Metal or laminate

Lead-Acid compared to Li-Ion

- Low number of distinct materials (Pb is 60% of battery mass)
- Design and material composition rarely varies by manufacturer
- Active materials composition does not change over time

Current Li-Ion Battery Recycling Processes

	Pyrometallurgical	Hydrometallurgical	Mechanical
Temperature	high	low	low
Materials recovered	Co, Ni	metal salts, Li_2CO_3 or LiOH	cathode, anode, electrolyte, metals
Battery sorting	not required	required	required

Our Closed-Loop Recycling Process

- Any lithium Ion battery (size, shape and chemistry)
- No sorting
- Synthesize new $\text{LiNi}_x\text{Mn}_y\text{Co}_z\text{O}_2$ directly
- Ratio of Ni, Mn and Co can be specially tailored to customer demands

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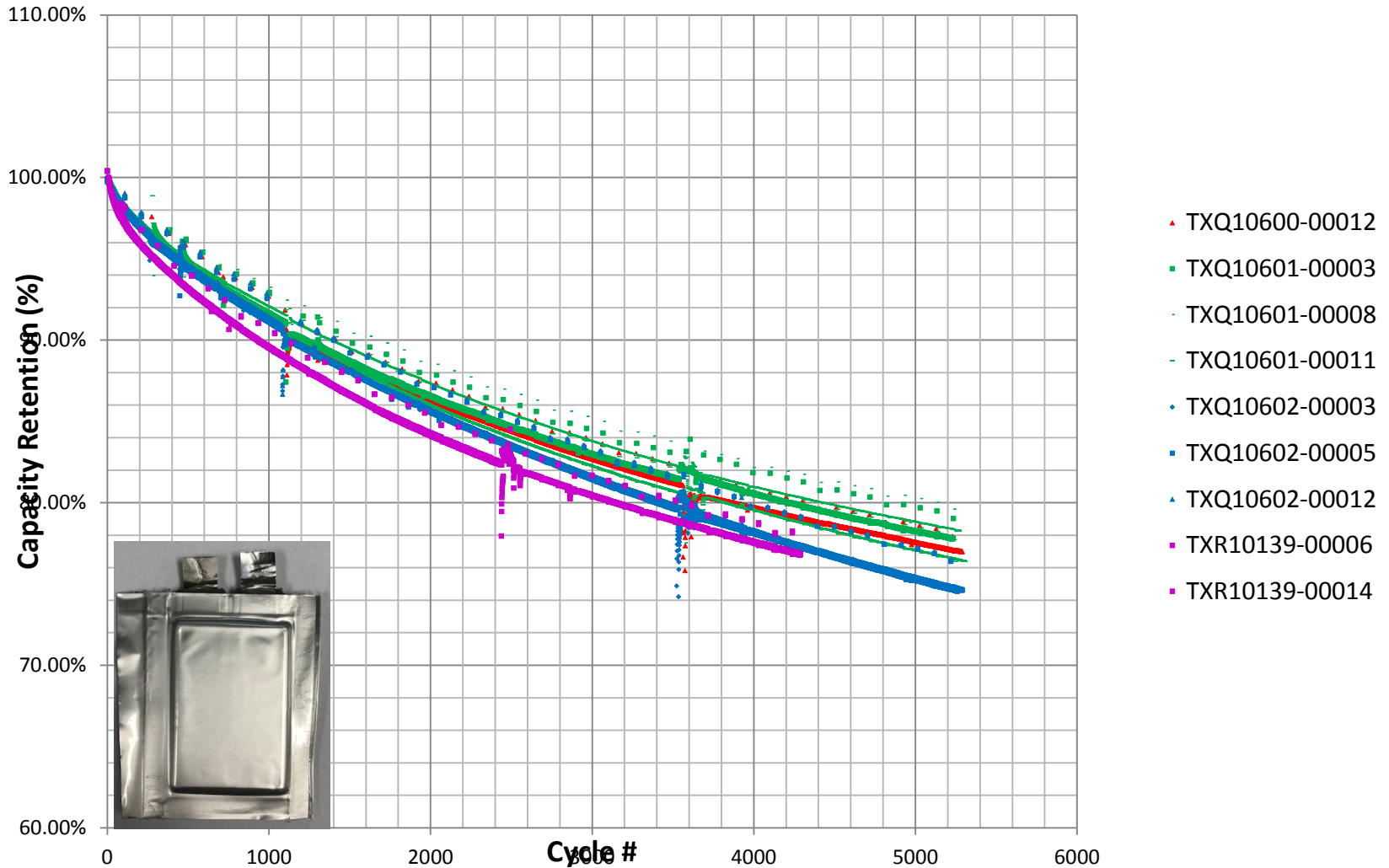
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Recovered NMC111

1C/2C, 4.15V-2.7V, 45°C, 100% DOD



From A123 Systems

Difference between Conventional and Solid Li-Ion Batteries

	Conventional	Solid state
Electrolyte	Liquid	Solid
Anode	Graphite	Lithium Metal

Current State of Solid Battery Recycling

NONE!!!

Challenges of Solid Battery Recycling

- Funding support
- Spent batteries
- Output materials
- Economic feasible
- Safety
- Recycle technologies
 - Discharging
 - Shredding
 - Separation
 - Li metal recovery