



The road to 1,000+ miles/charge for EV
The road to 600Wh/kg for EVTOL

- ETOP™
- Impervio™
- Eternalyte™
- SemiSolid™

Feb 2024



- Technology Overview
 - Innovative and Proprietary Process and Product Design Platforms
 - 24MSemiSolid™ – Electrode Platform
 - 24M ETOP™ – Electrode to Pack Product Design Platform
 - Electrode and Chemistry Agnostic
 - Advanced Materials
- Impervio™ Separator
- Lithium Metal Technology Suite
 - Eternalyte™ High CE Liquid Electrolyte
 - Impervio™ Dendrite Suppressing Separator
 - Zero Copper: Highest Gravimetric Energy Density
- Summary

24M ETOP™ - Highest Volumetric Efficiency

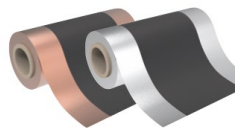
Electrode

Anode/Cathode Pair

Cell (3-4V)

Pack (300-600V)

Conventional



96-98%



Jelly Roll

72-85%



40-72%



<https://www.catl.com/en/news/958.html>

体积利用率
Volume utilization efficiency

72%

CTP 3.0 麒麟电池

CTP 3.0 Qilin Battery

2022

a. Solvent + Polymer

- a. Long Process, High Cost
- b. REACH, PFAS regulations
- c. No Direct Recycling

b. Dry Coating (No Solvent)

- a. No Direct Recycling

▪ Wound jelly roll placed into cans

- a. Numerous cans and connections
- b. Numerous busbars and cases

a. Module + Package (Traditional)

- a. Low energy density, high cost

b. CTP (Cell to Pack)

- a. Incremental efficiency improvement, but still insufficient

Electrode to Cell to Pack: 28-57%
(volume percentage of electrode in pack)

24m

24M SemiSolid™



93-97%



Unit Cell

ETOP™

• Direct packaging

- a. Low BOM, Low CAPEX, High Energy Density
- b. Flexible Size/Voltage, Low Carbon Footprint

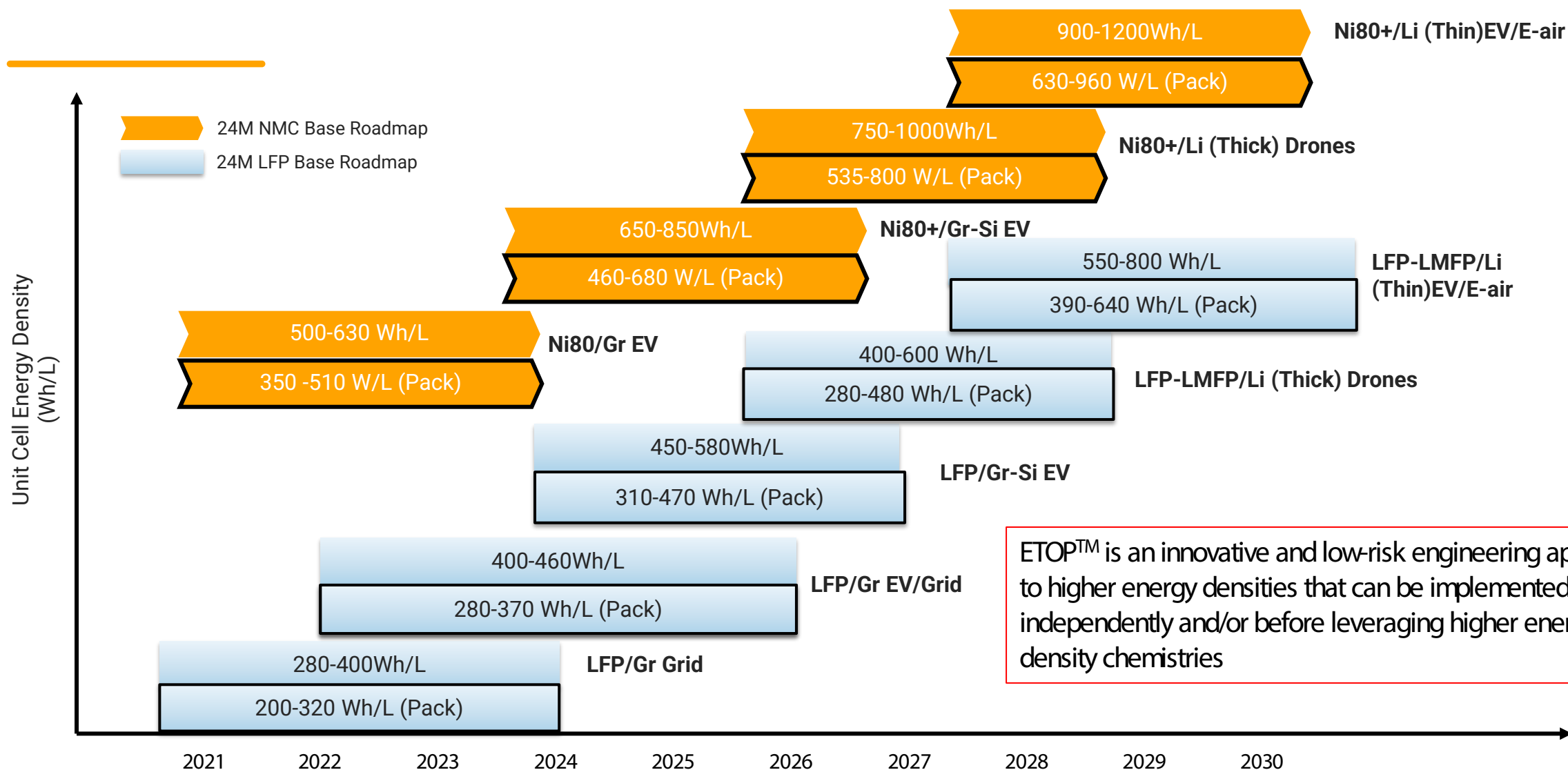


Direct Electrode to Pack: 70-82%
(volume percentage of electrode in pack)

- Direct Recycling, Low-Cost, High Safety
- Low Carbon Foot-Print

Chemistry Agnostic Process and Product Design Platforms

Ultra High Energy Density Enabled by ETOP™ Zero Cu (Unit Cell) Volumetric Energy Density

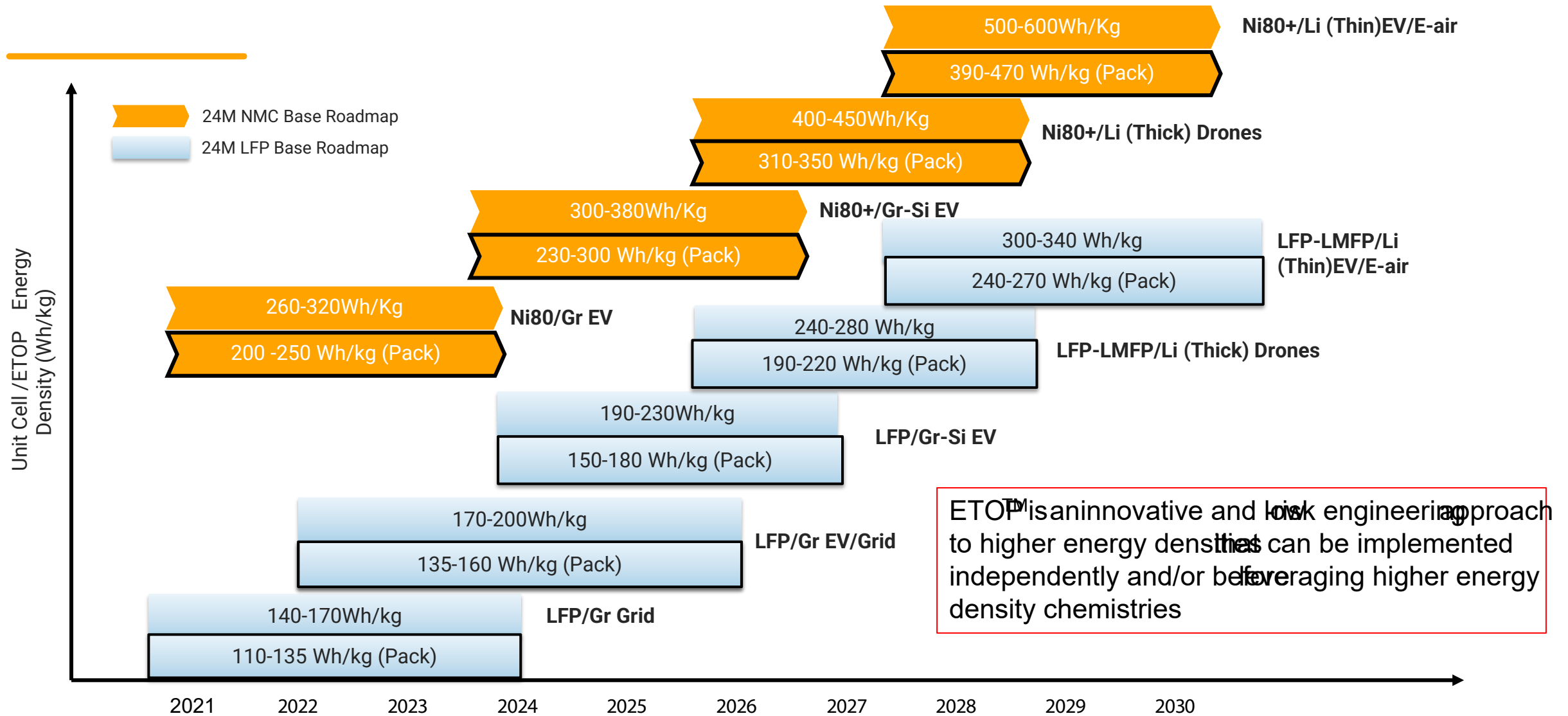


ETOP™ is an innovative and low-risk engineering approach to higher energy densities that can be implemented independently and/or before leveraging higher energy density chemistries

Source: 24M.

Chemistry Agnostic Process and Product Design Platforms

Ultra-High Energy Density Enabled by ETOP™ Zero Cu (Unit Cell) Gravimetric Energy Density



Transforming Lithium Ion Industry with Technology and Platform Business Model

			SemiSolid™ + ETOP	Conventional + ETOP	Conventional - ETOP
Platform	Electrode	SemiSolid™ Electrode	✓	-	-
		Conventional Electrode	-	✓	
	Product Design	Unit Cell/ETOP™	✓	✓	NA
		Winding/Metal Case/Pouch	-	-	
High Perform-Material	Lithium Metal Compatibility	Eternalyte™ (Long Cycle Life)	✓	✓	✓
		Zero Copper (Highest Energy Density)	✓	✓	NA
	Technology Features 1 st Implementations	Impervio™ (Superior Safety)	✓	✓	✓
		Announcing Soon	✓	✓	NA
		Announcing Soon	✓	NA	NA
Equipment	Production Method Innovations	SemiSolid™ Casting and Assembly	✓	NA	NA
		Announcing Soon	✓	✓	NA
	Announcing Soon	✓	NA	NA	
Regulatory benefit (CO2, PFAS, REACH)			✓	NA	NA
Overall cost / Efficiency			Best	2 nd	3 rd

24M Unlocks Massive Opportunity

Proven Technology in Market Today, fully Enables Lithium-Metal

Benefits All Technologies



HIGH SAFETY

- Zero cell fire risk

24m Impervio™, Unit Cell

- Prevents internal shorts in Li-metal, others

SemiSolid™
+ETOP



Conventional
+ ETOP



Conventional
No ETOP



LONG RANGE, RESALE VALUE

- 600-1000 miles

24M Impervio™, ETOP™, Eternalyte™

- Enables Li metal + highest pack energy, 20-year life



FAST CHARGE, LOW TEMP

- 200 miles in 3 mins
- -20 degree C operation

24M Eternalyte™, e2Heat™ (Individual Heater)

- High efficiency, long cycle life, even at low temp



LOW COST

- \$80/kWh pack level

24M SemiSolid™, ETOP™, Series Formation

- Cuts 50% of CapEx, 30% of pack cost



SUSTAINABLE

- 98% material recovery

24M SemiSolid™ LiFoever™ (Direct Recycling)

- Direct re-use of active materials



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Impervio™ Separator: Eliminate Mass Recalls and Enable Metal Cells

- Proprietary and patented advanced separator technology
- Prevents fires caused by dendrites in conventional and lithium metal cells
 - Numerous reports state that solid state electrolytes do not prevent dendrite formation
- Eliminates mass recalls by detecting defective cells before catastrophic events
- Provides ultimate safety utilizing Impervio™ detection signal to trigger fail safe current interrupt device
- Compatible with all major technologies and applications
 - SemiSolid™ technology
 - Conventional lithium technology
 - Lithium metal anodes with lithium dendrite growth prevention
- 24M Press Release

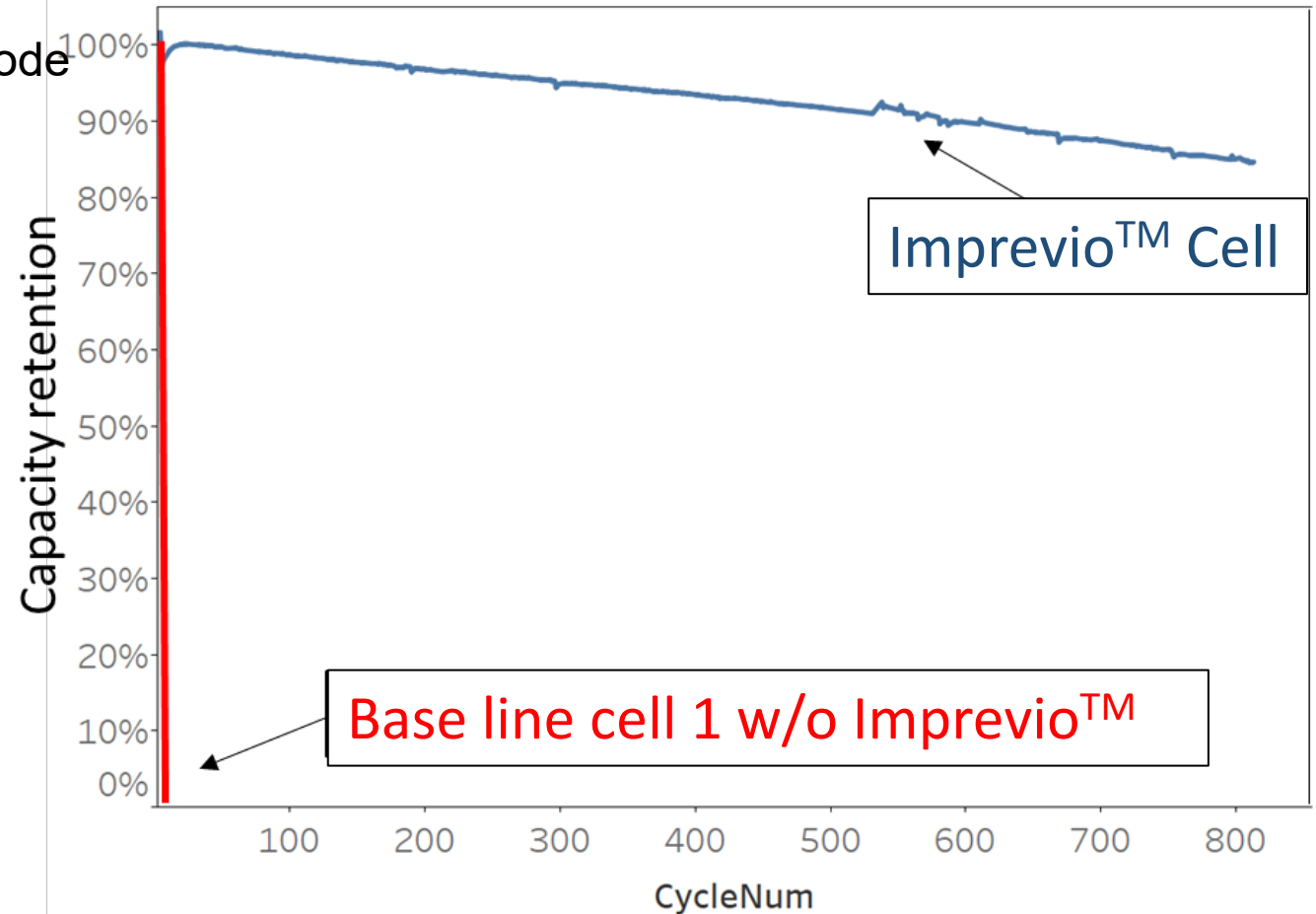
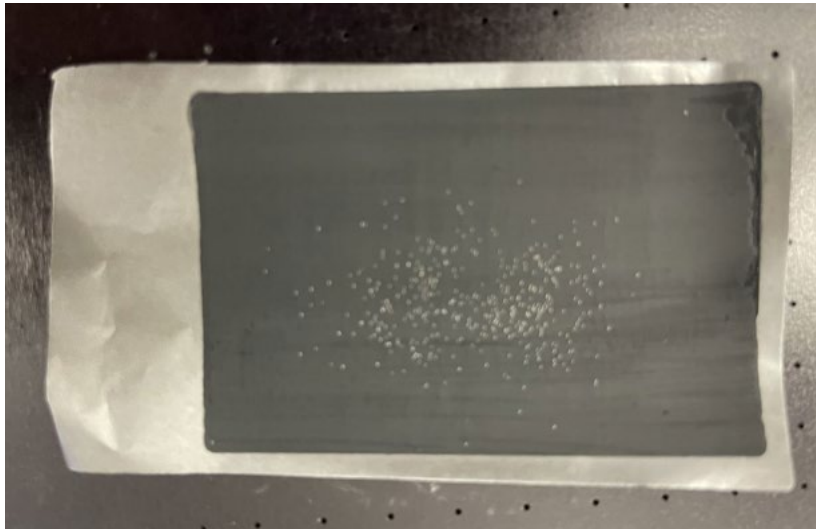
Recent Lithium Battery Fire Incidents



Imprevio™ - Prevents Dendrites from Metal Contamination

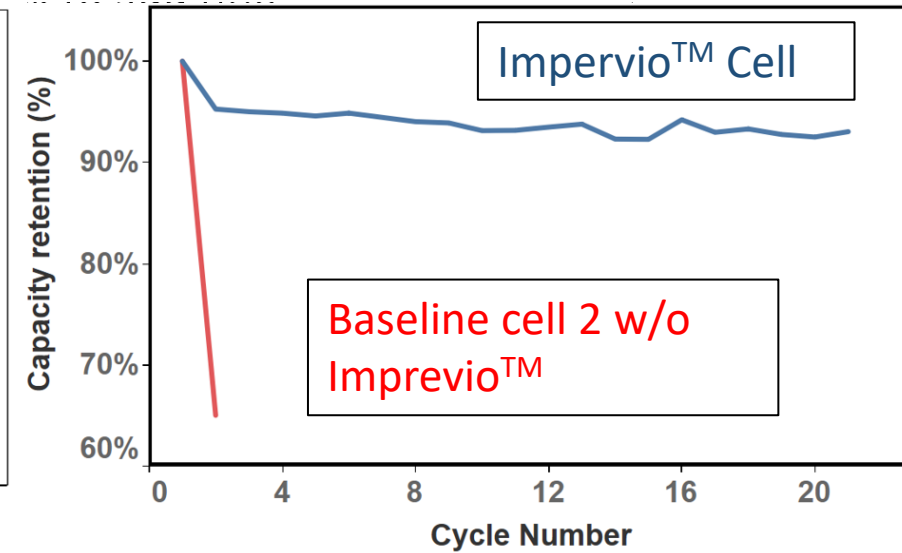
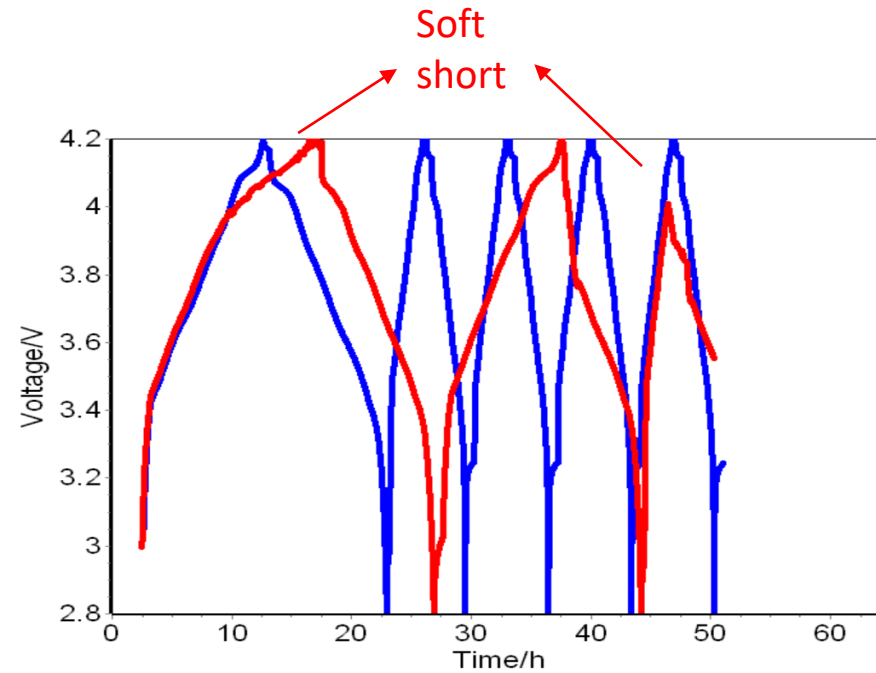
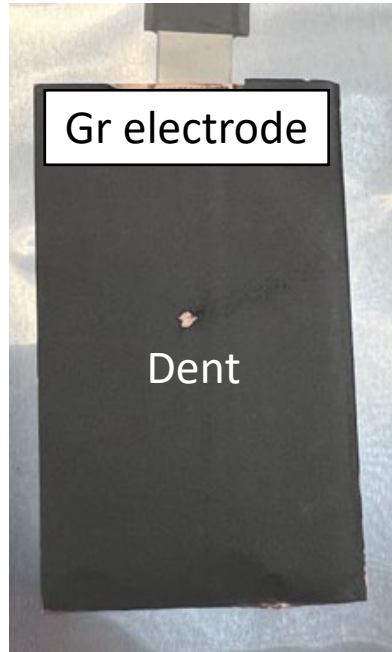
Metal Contamination Removal

- Added ~1 % stainless steel contamination to cathode



Baseline cell shorted after formation while Imprevio™ cell has surpassed 800 cycles with over 83% capacity retention

Impervio™ - Prevents Lithium Dendrites



NMC – Graphite Cell

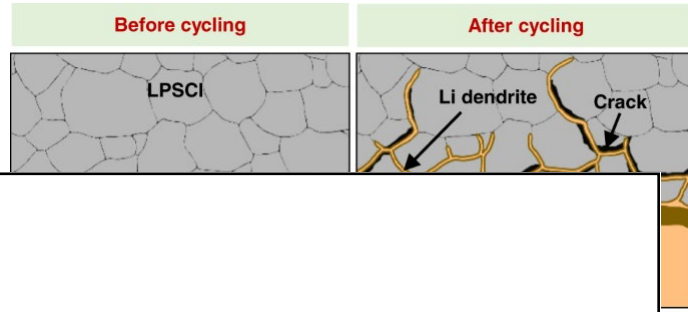
0.1C charge/discharge for one cycles then 0.33C charge/discharge

- Stable coulombic efficiency during cycling indicates no soft short between cathode and anode

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Lithium Metal Cells: Solid State and Liquid Electrolyte Limitations

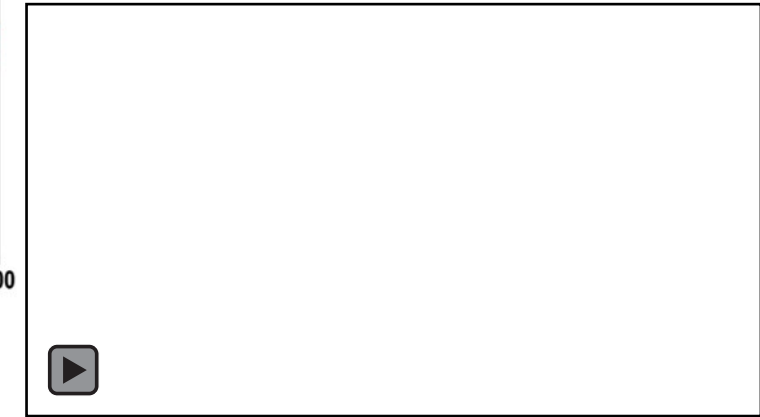
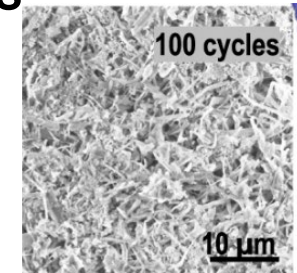
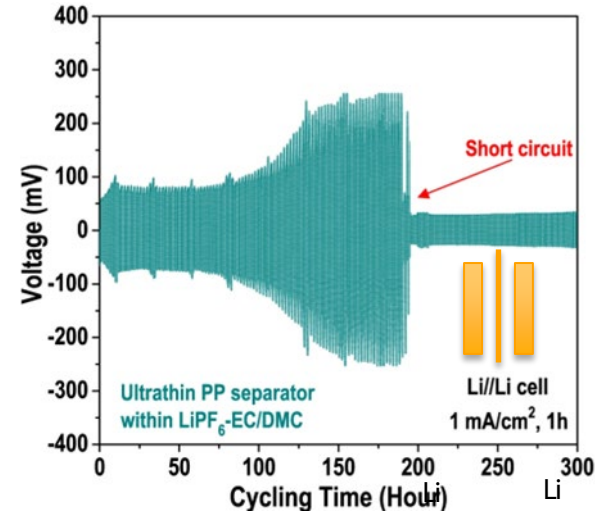
Solid State Electrolytes



Nature 2022

- Claim to block the lithium dendrites but paper published in Nature shows the opposite – solid state electrolytes promote dendrite growth

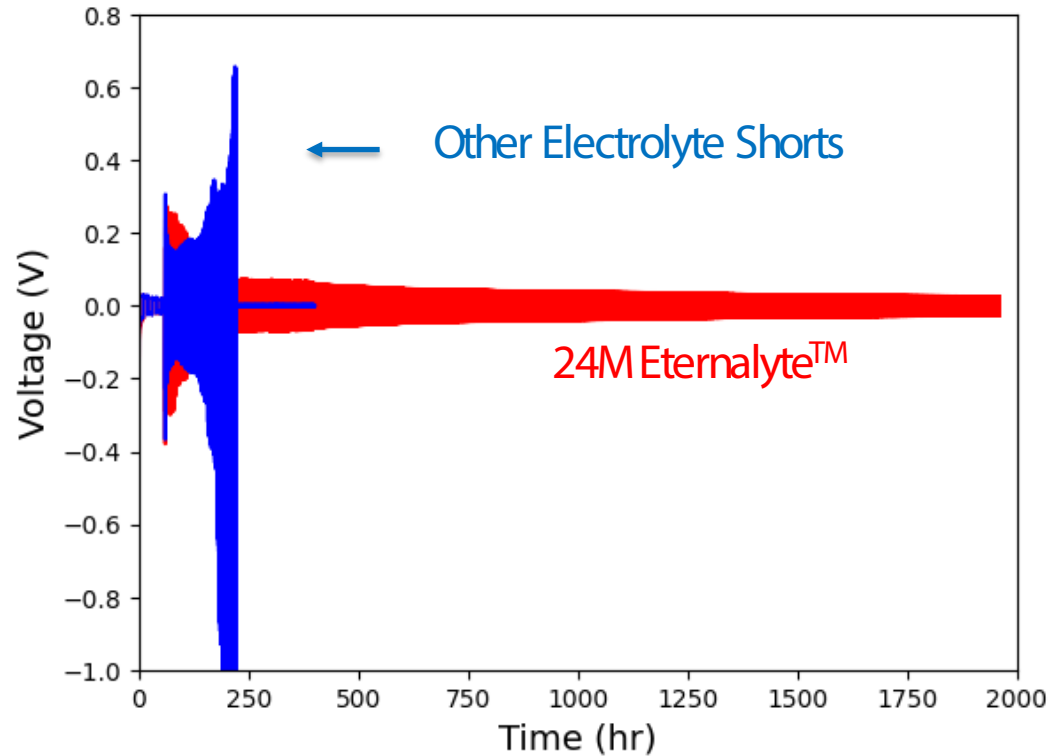
Liquid Electrolytes



Angew Chem Int Ed Engl
2018 May 4;57(19):5303.

- Nat Commun 13, 6788 (2022).
- Plates dendritic lithium which pierces separator and shorts cell (plating current density <math>< 3\text{mA/cm}^2</math>) Have continuous side reactions with plated mossy lithium that consumes electrolyte and lithium
- Cause continuous ASI growth

Eternalyte™: Li/Li Cell Cycling Data

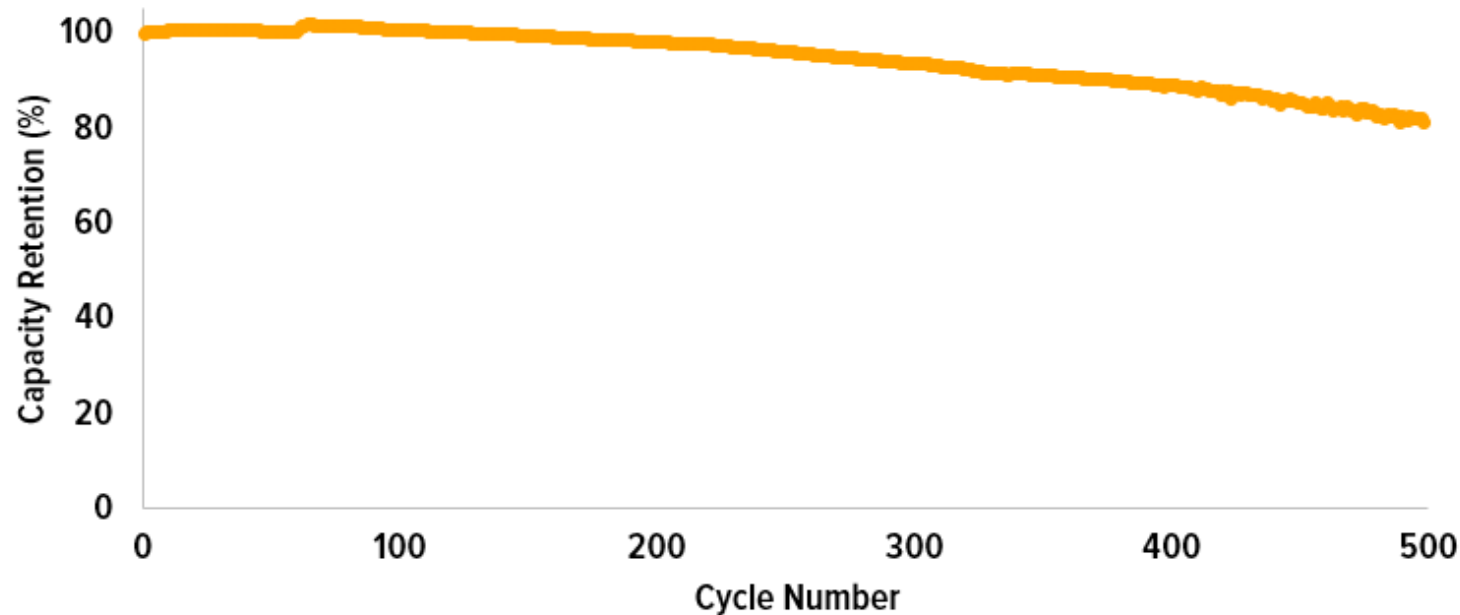


Rate	<u>20mA/cm²</u>
Temperature	25°C
Areal Capacity	5 mAh/cm ²
Electrode	50 um Li

- Low overpotential and long cycling time without hard short implies that Eternalyte™ can prevent dendrite formation even under fast charge/discharge conditions in full cell
- Eternalyte™ offers good Li/Li cycling efficiency
- To our knowledge Eternalyte™ achieves the highest stabilities under 20mA/cm² plating/stripping current for a liquid electrolyte

Eternalyte™: High Stability Liquid Electrolyte for Lithium-Metal Cells

1,400 km+ per charge in the same size battery pack



Cycle Rate	1C/1C
Cathode	NMC 3mAh/cm ²
Anode	50um Li metal
Unit Cell energy density	391 Wh/kg, 887 Wh/l
ETOP™ Pack Energy density	350 Wh/kg, 665Wh/L

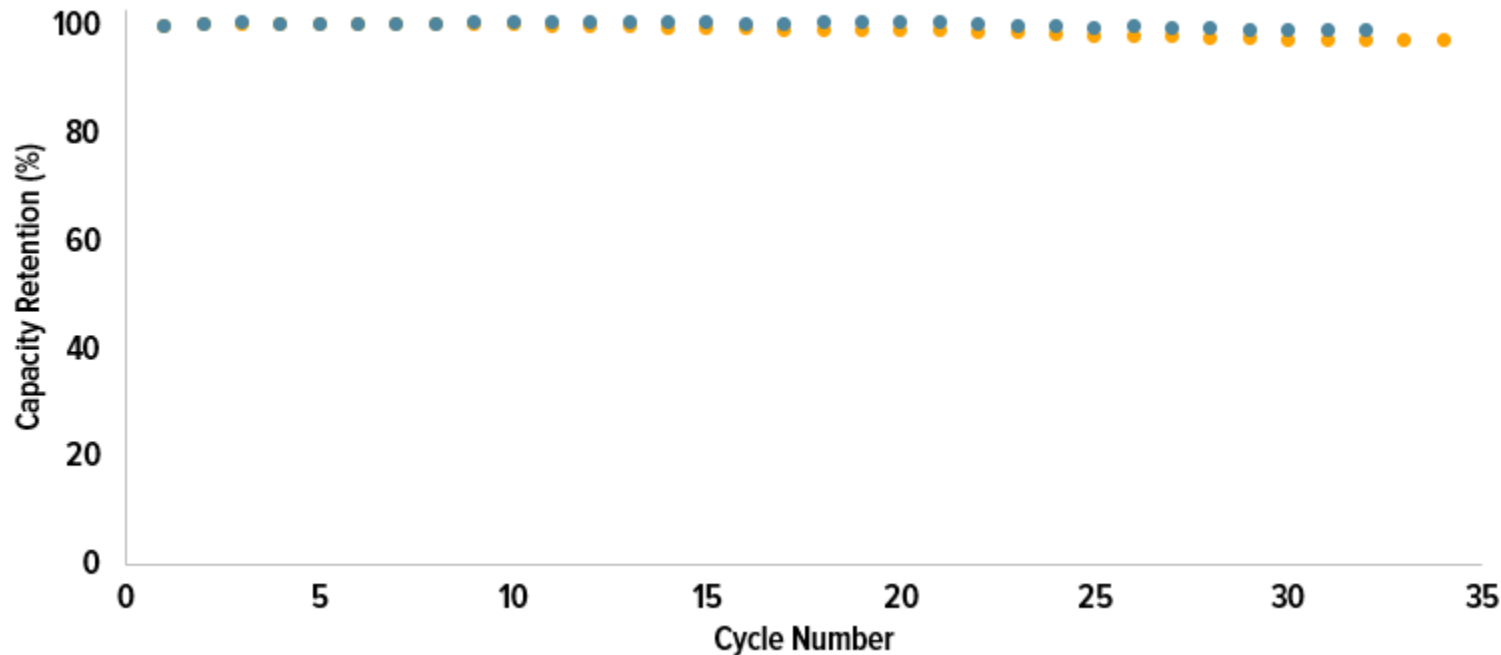
Reference:
71.4KWh Pack, 243KWh/L Energy Density
=500 Km Driving Range (STD)

- Lithium metal/NMC cell cycling **1C/1C** (others show data with c/10 or c/6 charge)
- The cell retains 83% capacity over 500+ cycles (500,000 km+ Range)
- The average CE is ~99.9%

Lithium Metal NMC Cell with Eternalyte™ and Impervio™

Enables consistent, long cycle life with high energy density lithium metal

2,000 km per charge in the same size battery pack
-Further optimization on going



- High energy density lithium metal NMC cell cycling at 1C/1C
- Capacity retention is 99% over 34 cycles
- The average CE is 99.9%

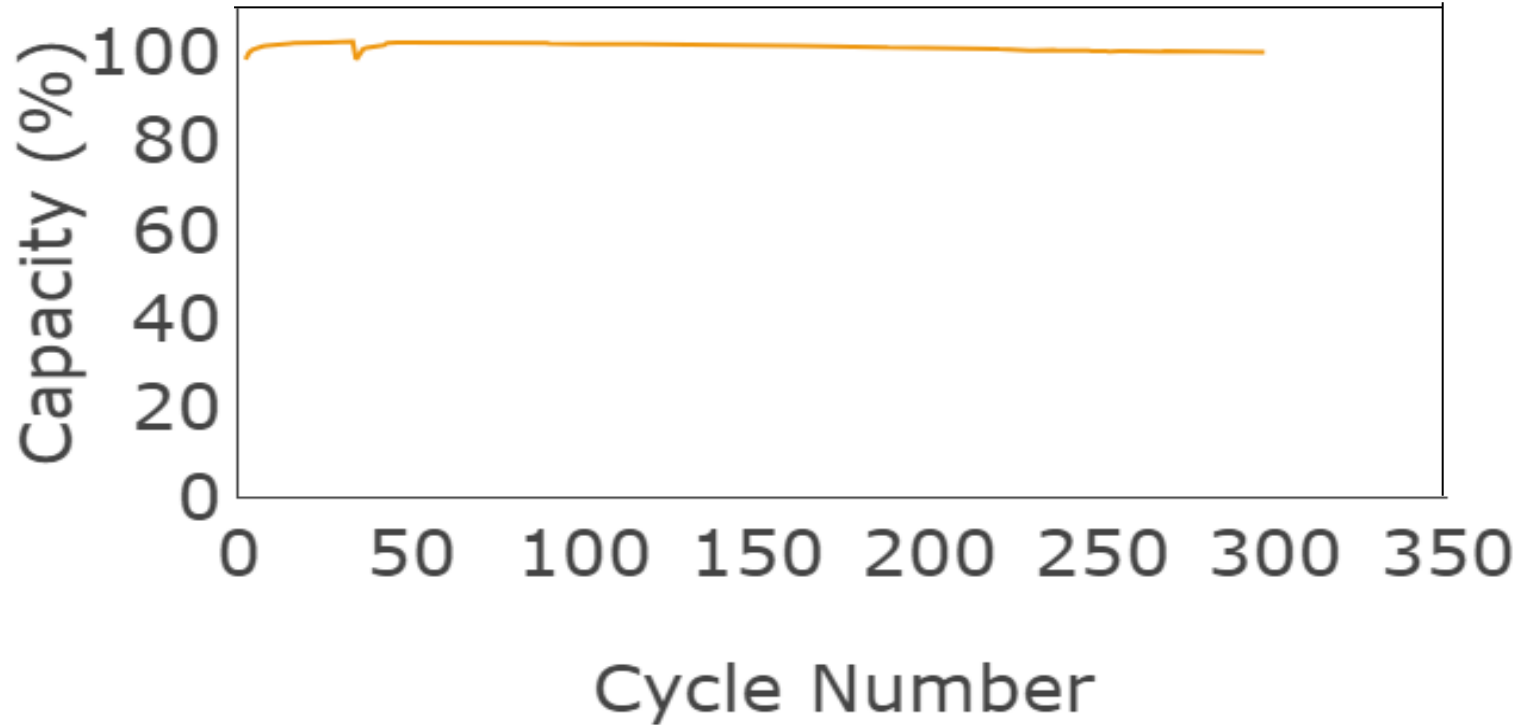
Cycle Rate	1C/1C 3.0-4.1V
Cathode	NMC 3mAh/cm ²
Separator	Impervio™
Electrolyte	Eternalyte
Anode	50um Li metal
Unit Cell energy density	391 Wh/kg, 887 Wh/l
ETOP™ Pack Energy density	350 Wh/kg, 665Wh/L

Reference:
71.4KWh Pack, 243KWh/L Energy Density
=500 Km Driving Range (STD)

Lithium Metal LFP Cell with Electrolyte and Impervio™

Enables consistent, long cycle life with high energy density lithium metal cell

950 km+ per charge in the same size battery pack even with LFP chemistry
Further optimization ongoing



Cycle Rate	1C/1C
Cathode	LFP 2.5mAh/cm ²
Separator	Impervio™
Electrolyte	24M Standard
Anode	50um Li metal
Unit Cell Energy Density	500 Wh/L 220 Wh/kg

Reference:
71.4KWh Pack, 243KWh/L Energy Density
=500 Km Driving Range (STD)

- Lithium-metal LFP cell cycling 100% capacity over 300+ cycles (improved consistency from Impervio™)
- The average CE is ~99.9%, no significant results with multiple cells

Advantages of SemiSolid™ Cathode Coupled with Lithium Metal Anode

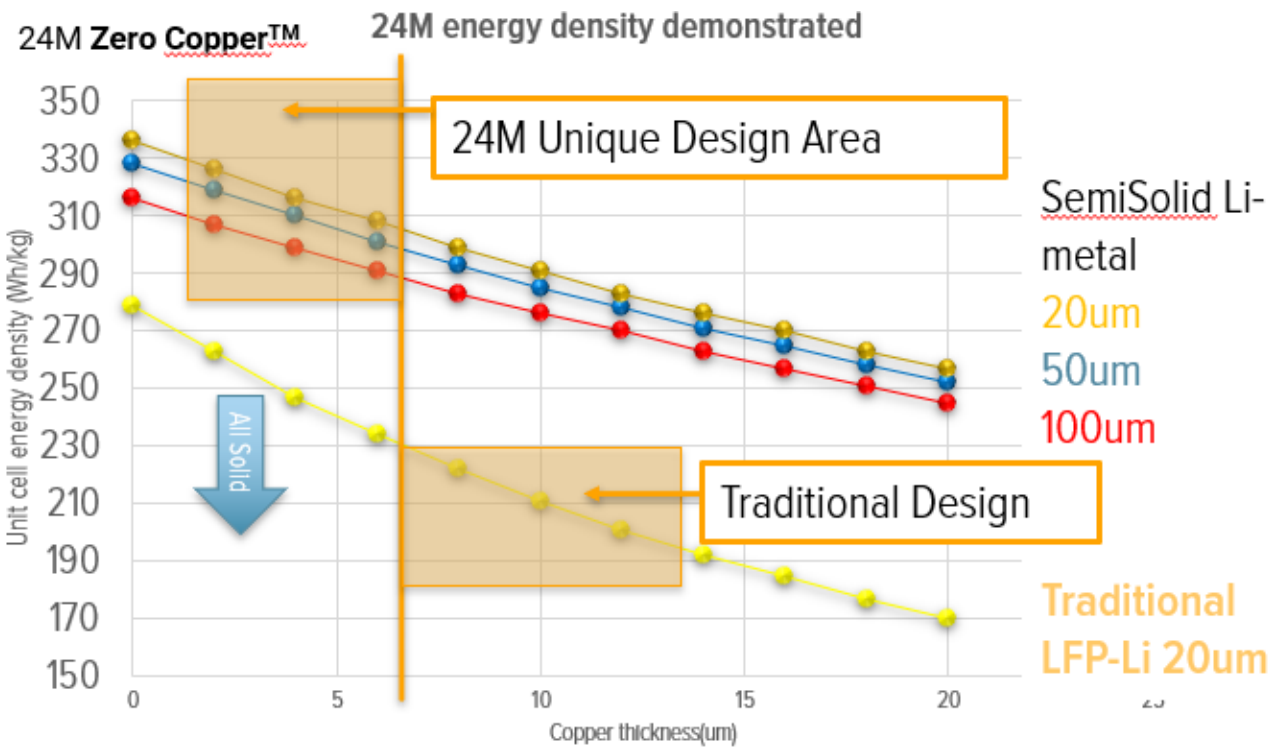
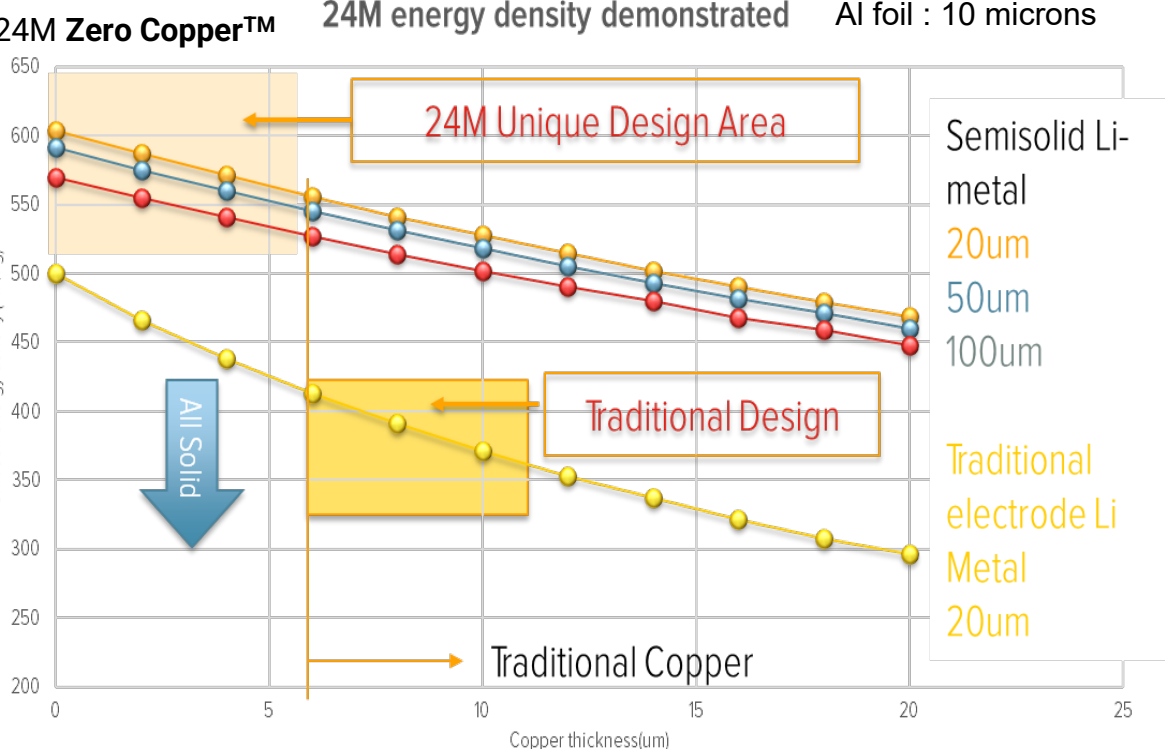
Reduction of Copper thickness is the key for EVTOL

Assumption:
 24M Thick LFP: 7.7 Ah/cm^2
 Traditional LFP: 3 mAh/cm^2
 Al foil: 10 microns

▪ **NMC/Li cells**

Assumption:
 24M Thick NMC: 10 Ah/cm^2
 Traditional NMC: 4 mAh/cm^2
 Al foil: 10 microns

LFP/Li cells



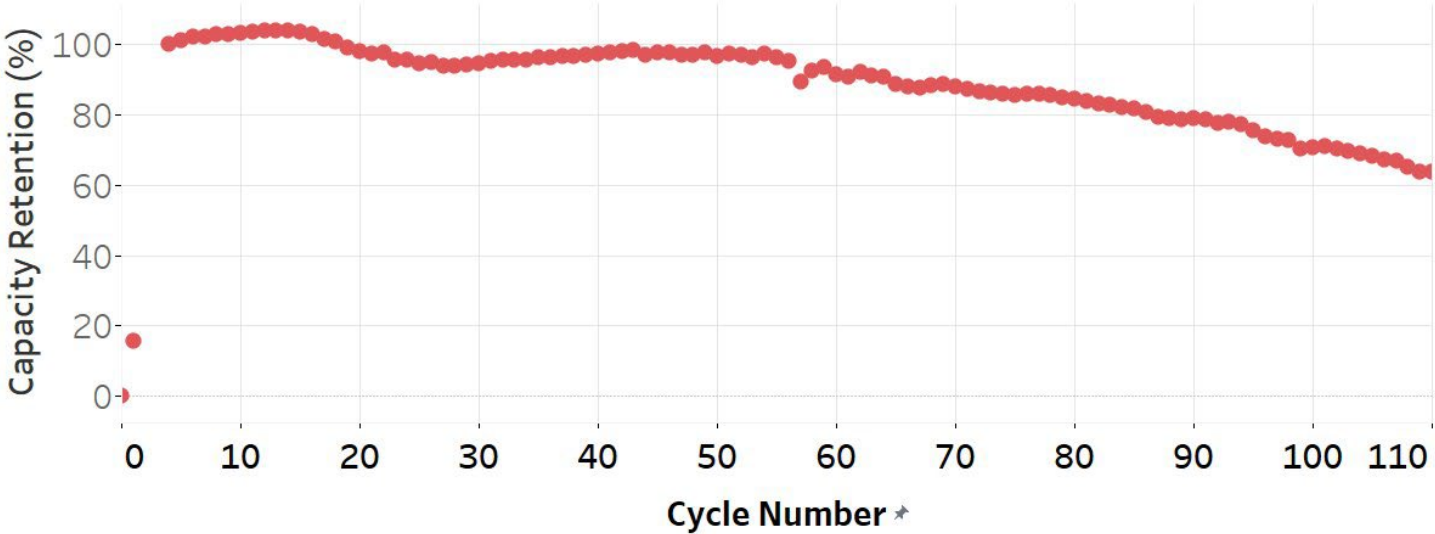
24M's Unit Cell with Zero Copper and thick cathode shows a significant gravimetric energy density improvement
 24M's Unit Cell will provide a significant safety and reliable advantages to the conventional format



24MSemiSolid™+Eternalyte™+ Impervio™+ 24M ZeroCopper™

Enables consistent cycle life with ultra-high energy density lithium metal

2,600 km per charge in the same size battery pack
 -Further optimization on going



Rate	1/5C /1/3D
Temperature	30°C
Areal Capacity	13mAh/cm ²
Cathode	NMC
Separator	Impervio™
Anode	20 um Li
Unit Cell Energy density	570Wh/kg, 128Wh/l
ETOP Pack Energy density	500 Wh/kg, 880+Wh/L

Reference:
 71.4KWh Pack, 243KWh/L Energy Density
 =500 Km Driving Range (STD)

- Enables highest energy density lithium metal cycling
- The cell retains 80% capacity over 100+ cycles
- The average CE is ~99.9%

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Summary Enabling 1,000 Mile per Charge Battery Pack

- **ETOP™**
 - Provides for the highest volumetric and gravimetric pack energy densities
 - Achieves equivalent pack level energy densities using LFP electrodes as conventional packs using NMC cells
- **Impervio™ Separator**
 - Eliminate mass recalls and achieve next level safe
 - Consumes metal dendrites and provides for fail safe mechanism – critical functions as energy density increases
 - Cycle life consistency with lithium metal cells
 - Eliminates short circuits from randomly occurring lithium dendrites
- **Eternalyte™**
 - Liquid electrolyte that achieves excellent cycle life with lithium-metal cells under high charge rate
- **24M Zero Copper™ with 24M SemiSolid™ Electrode**
 - Demonstrated highest gravimetric energy density with lithium-metal NMC cell: **600Wh/kg** at Unit Cell level
- **1000+ miles/Charge**
 - Combining ETOP™/Eternalyte™/Impervio™ enables safe EVs that have much longer range than ICE cars

24m