



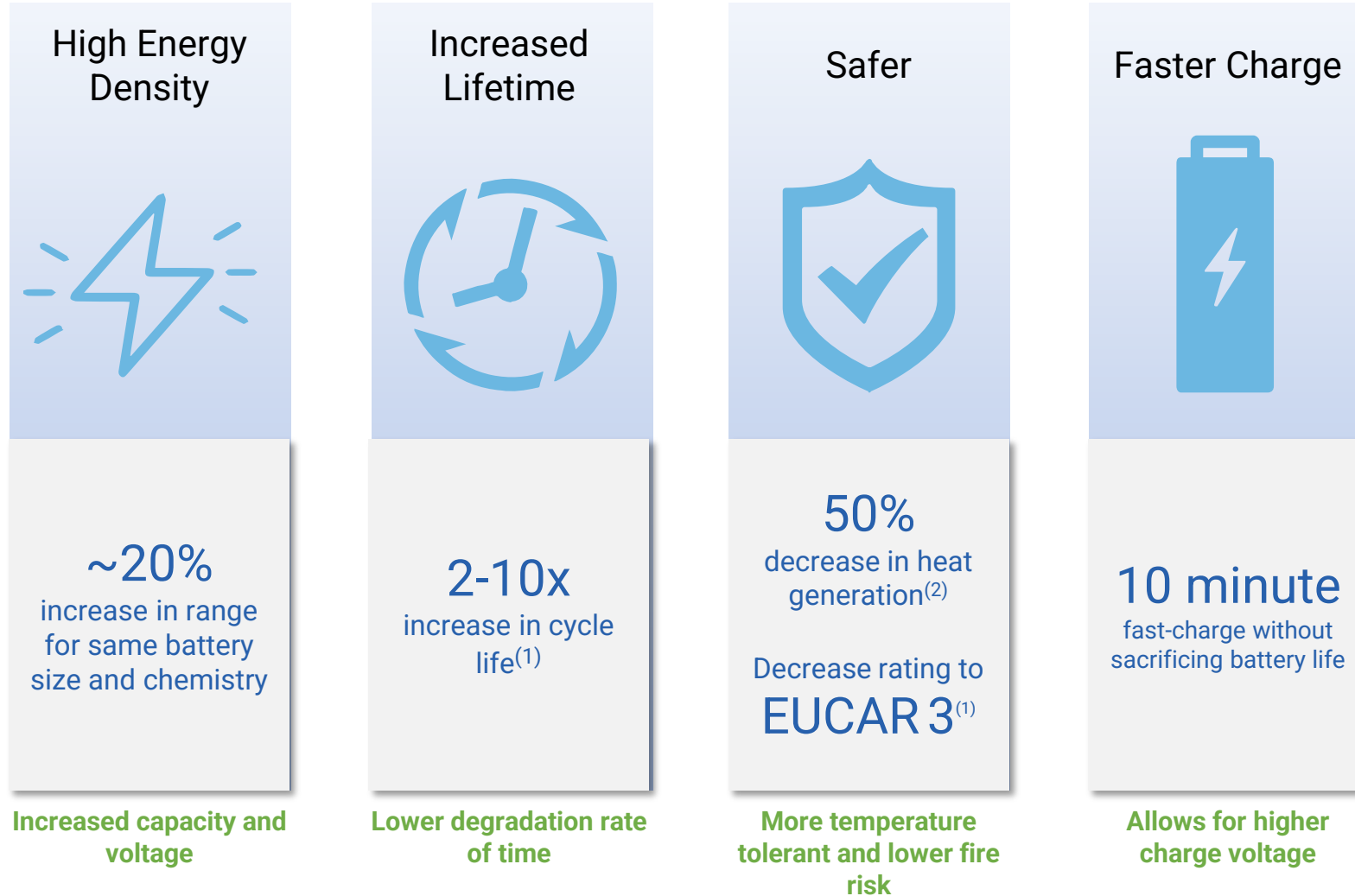
Advanced ALD Coated Lithium-Ion Batteries

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Introduction

- Forge Nano is the industry leader in Atomic Layer Deposition (ALD)
- ALD coating is the process of material coating at the molecular level applying an uniform and consistent coating.
- Forge Nano is the only company capable of performing ALD coatings to scale
 - ◆ Forge Nano ALD is capable of coating numerous materials on various materials and products.
 - ◆ I am focused on ALD coating on battery anode and cathode powders to improve the performance of the lithium-ion battery cells
- In this presentation I will:
 - Address the performance benefits of ALD coatings on battery materials
 - Provide an introduction on a new Forge Nano developed ALD 0V performing cell.

The Nanocoating Makes Batteries Better



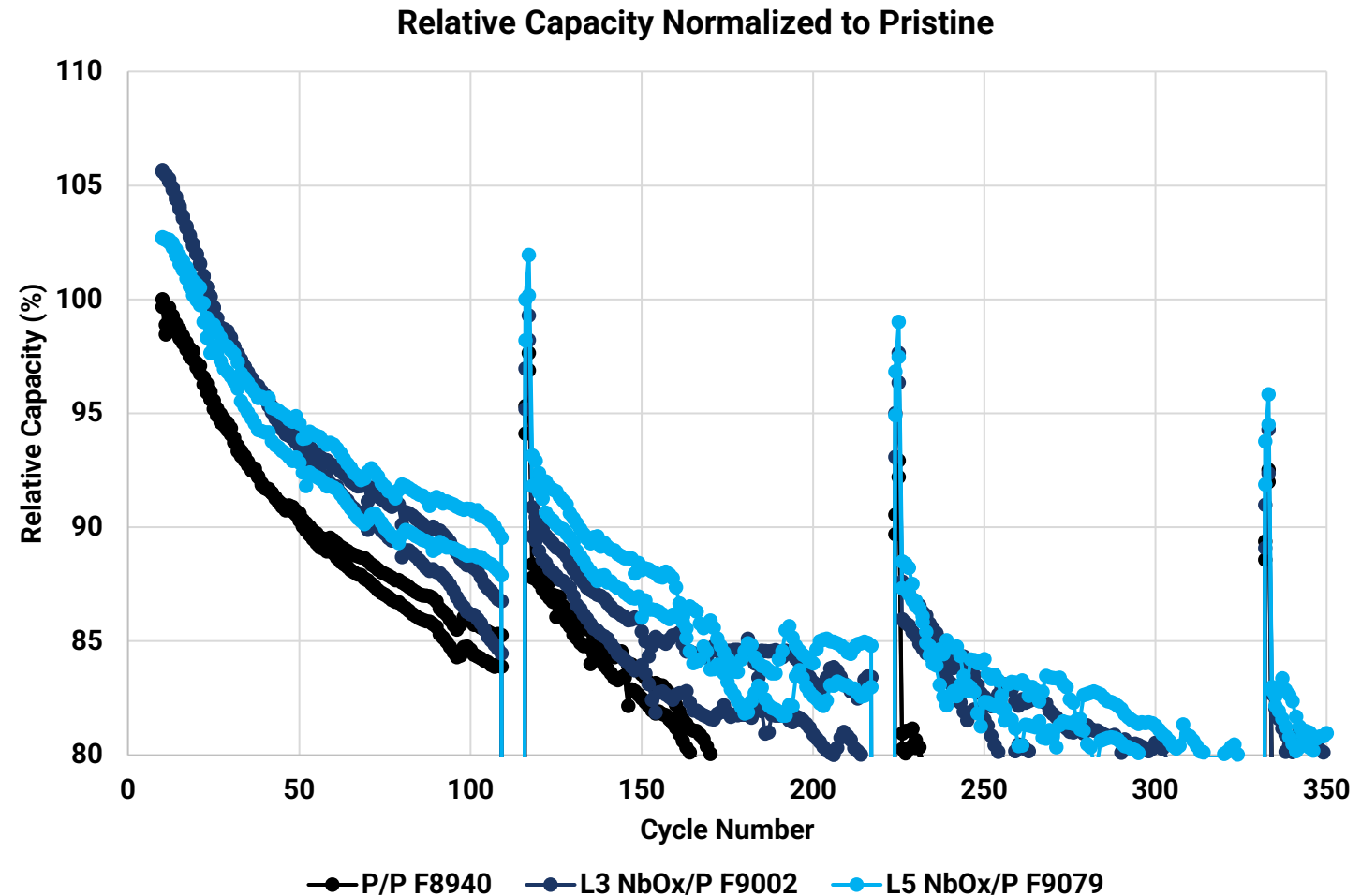
(1) Independently validated by major auto manufacturer
(2) Quantified by % reduction in exothermic energy from arc test.
(3) Projected for full-scale production based on detailed cost modeling.

ALD Benefits on NMC811 Cathode Materials

Niobium Oxide increases BOL capacity by 5% and cycle life by 77%

Testing Conditions

Counter Electrode: Natural Graphite
Loading: 10 mg/cm²
Temperature: 30°C
Voltage: 3.0-4.2V
Cycling Condition: CC-CV until C/20
Formation: x3 0.1C/0.1C
Pulse DCIR: at 60% SOC every 100 cycles
SOH: x2 0.1C every 100 cycles
Cycling: 0.5C/1C

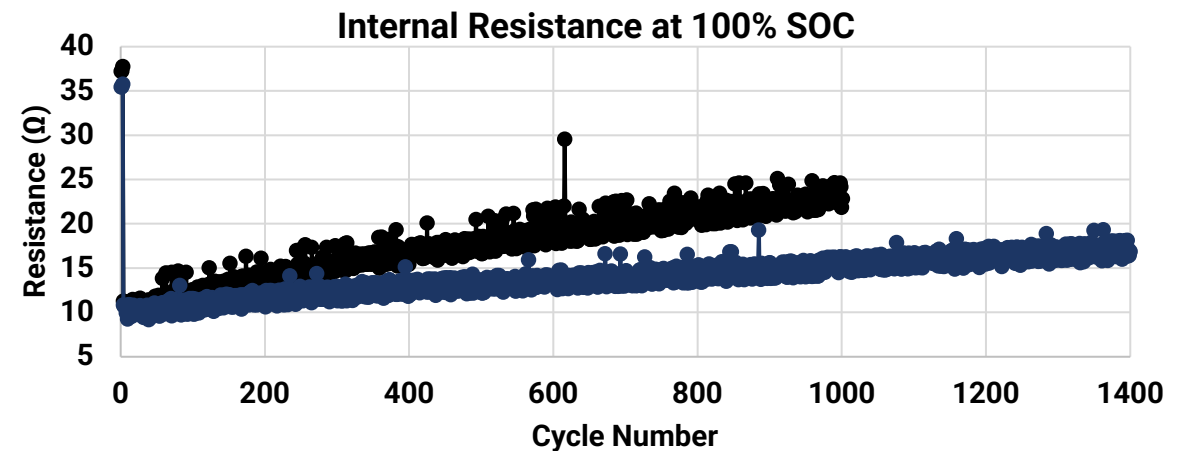
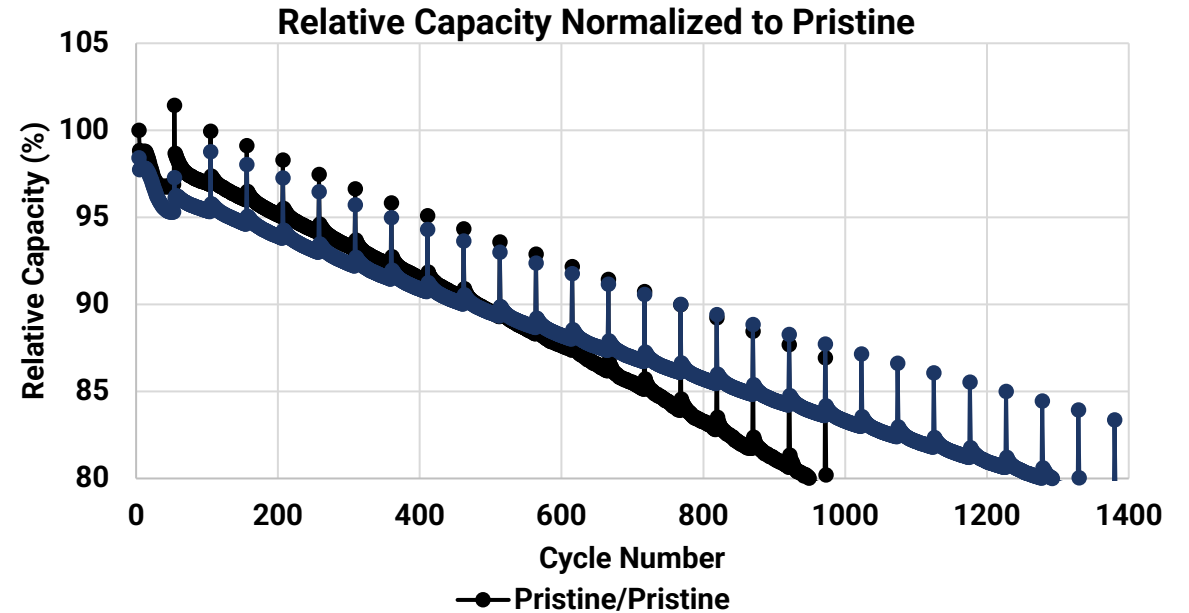


ALD Benefits on NMC811 Cathode Materials

ALD increased lifetime by 37% and reduced resistance growth by 36%

Testing Conditions

Counter Electrode: Natural Graphite
Loading: 20 mg/cm²
Temperature: 30°C
Voltage: 3.0-4.2V
Cycling Condition: CC-CV until $I < C/20$
Formation: x3 0.1C/0.1C
SOH: x1 0.33C every 50 cycles
Cycling: 0.5C/0.5C



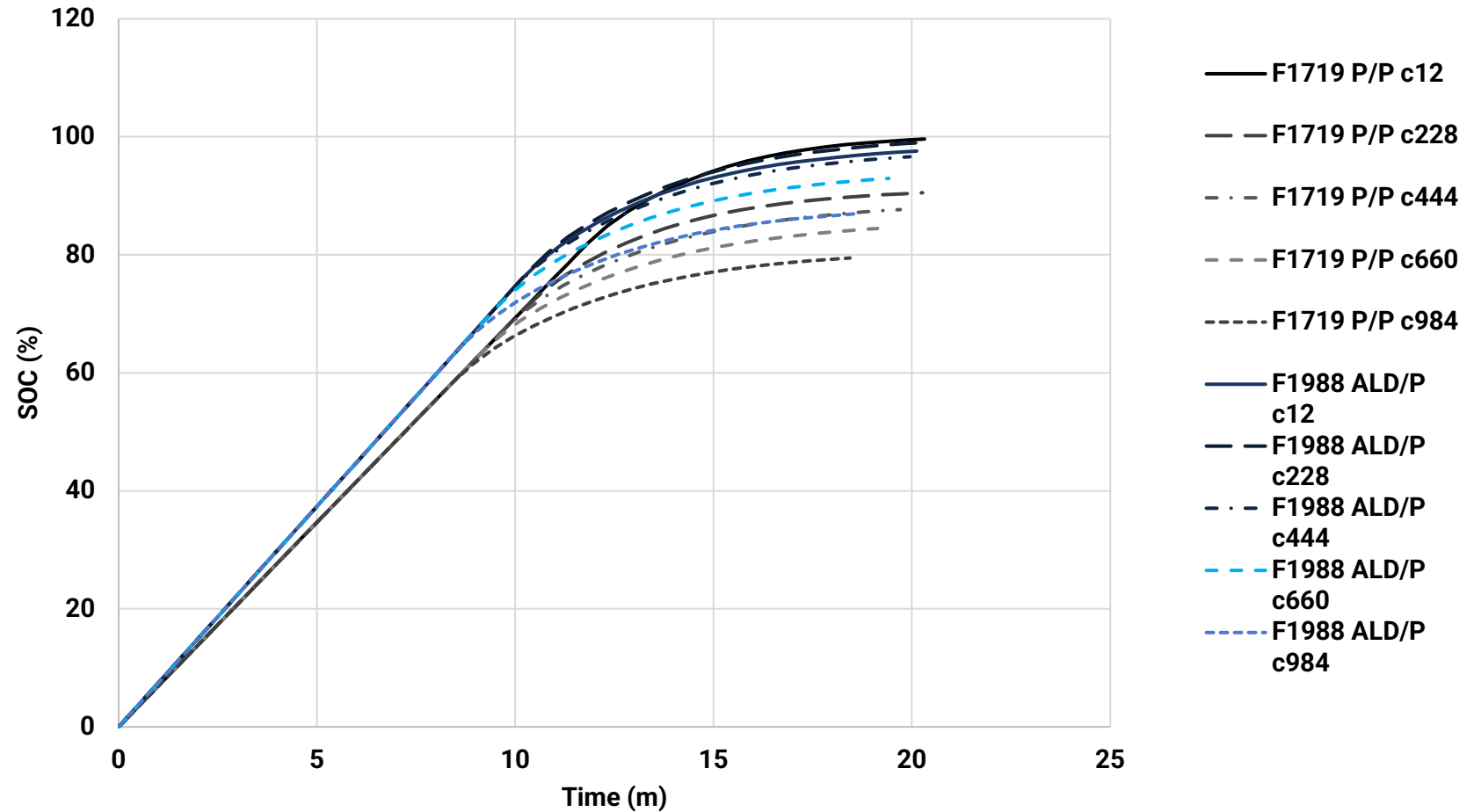
ALD Benefits on NMC811 Cathode Materials



ALD reaches 80% SOC in 11 minutes

Testing Conditions
Counter Electrode: Natural Graphite
Loading: 10 mg/cm²
Temperature: Ambient
Voltage: 3.0-4.2V
Cycling Condition: CC-CV until C/20
Formation: x3 0.1C/0.1C
Pulse DCIR: at 60% SOC every 100 cycles
SOH: x2 0.1C every 100 cycles
Durability: 4C/1C

State of Charge vs Time

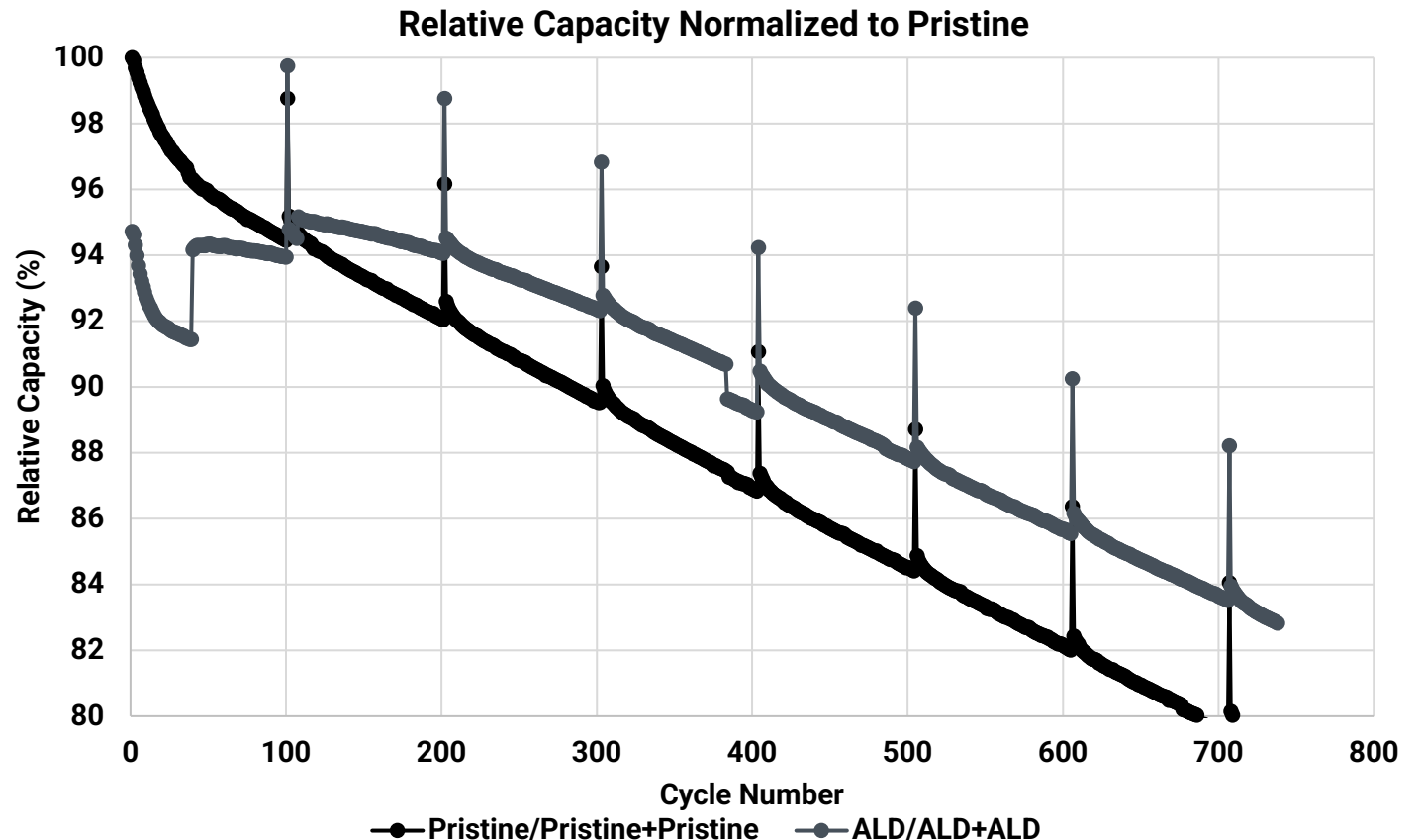


ALD Benefits on NMC811 Cathode Materials and Graphite/Silicon Anode Materials

ALD on Anode and Cathode increased capacity retention (energy density) and cycle life

Testing Conditions

Counter Electrode: Silicon + Natural Graphite
Loading: 10 mg/cm²
Temperature: 30°C
Voltage: 2.5-4.2V
Cycling Condition: CC-CV until C/20
Formation: x3 0.1C/0.1C
EIS: at 40% SOC every 50 cycles
SOH: x1 0.33C every 50 cycles
Cycling: 0.5C/1C

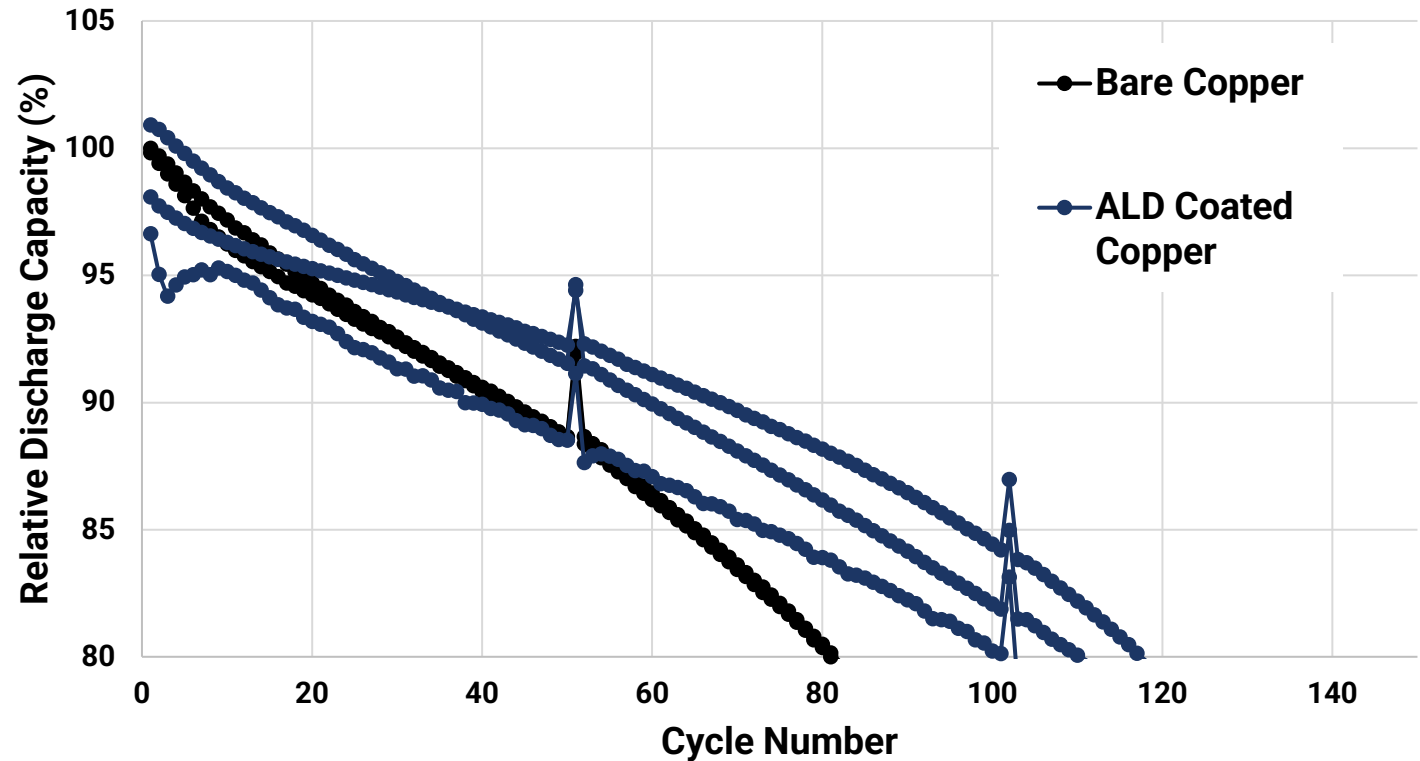


Benefits of ALD Coatings for New 0V Cell Technology

- *TiN coated Cu extends cycle life compared to bare Cu when cycling between 0-4.4V*

Testing Conditions
Material: NMC 811 vs Natural Graphite
Temperature: 30°C
Cycling Condition: CC-CV until C/20
Formation: 3.0-4.4V x3 0.1C/0.1C
SOH: x1 0.33C every 50cycles
Cycling: <u>0-4.4V 0.5C/1C</u>

Discharge Capacity Relative to Bare Copper Performance





FORGE NANO

Thank you for your interest

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