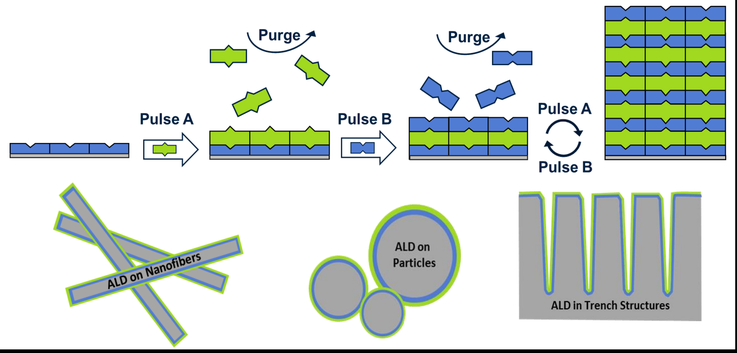
Reducing the Cost and Energy of Li⁺ Battery Manufacturing Using High Throughput ALD Processes

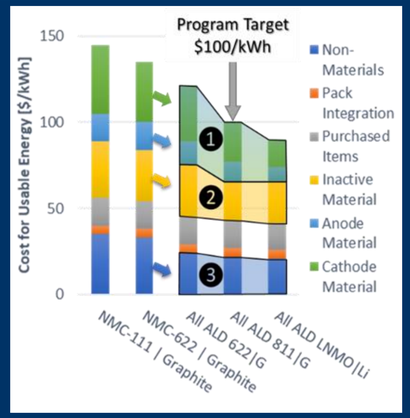
Project ID: bat565

ABOUT FORGE NANO

- Leader in Atomic Layer Deposition (ALD)
  - Conformal nano-coatings
    - On powder substrates
    - On wafers & complex 3-D substrates
- Focus on innovative materials solutions
- Offering tools and service from R&D to Commercial scale (milligrams-kilotons)
- Developing new products with partners

ATOMIC LAYER DEPOSITION



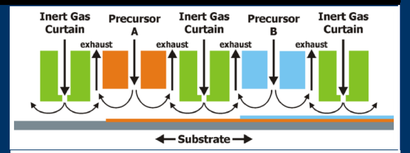


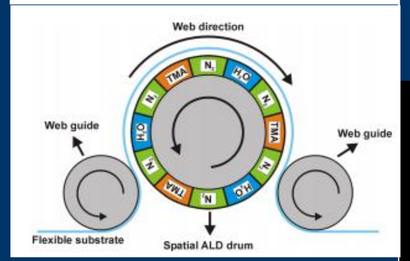
PROJECT GOALS:

Reduce Manufacturing Costs via ALD !

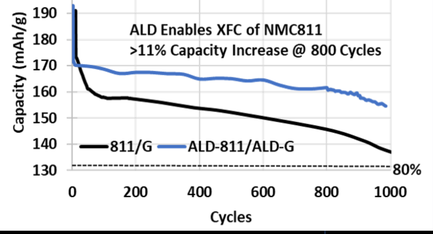
ALD on Anode & Cathode powders
- Cycle life, cap. retention, higher V
- → reduced active materials cost

Roll-Roll ALD on Separators
- Improved wetting, formation, aging → Reduced time/energy
- Thermal stability → Improve Safety



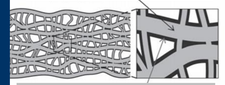


ALD on Anode+Cathode powder: Better Fast Charge Cycle Life 4.2V, 4C/-1C

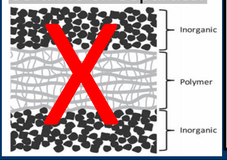


Separators testing:
Celgard 2400
vs.
Celgard 2400 with ALD
vs.
Ceramic particle coated (nano alumina) - thicker

ALD on Separator:



Ceramic on Separator:



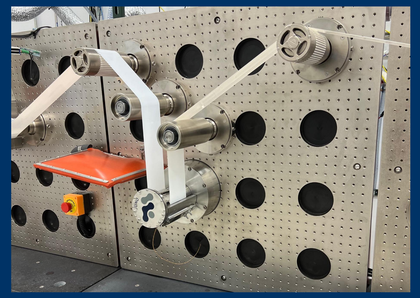
Separator Goals	
Parameter	Program Target
Thickness	< 20 µm
Wettability	Full wet-out
Average Pore size	Nominally the same as uncoated
Thermal Stability	<1 % shrinkage/90°C
Cost	< $0.60/m² (effective)
Shutdown Temperature	105 °C (fully tunable)
Manufacturing Speed	50 m/min
Moisture	<150 ppm

PROGRESS:

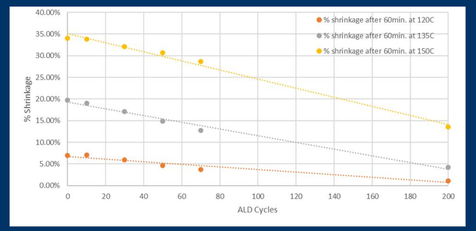
ALD on Anode & Cathode powders:
- ORNL pouch cells validates data from FN coin cells
- ALD improves C-rate, Stability

ALD on Separators:
1) Batch ALD
- Wetting, thermal stability, rate →

2) ALD on Separators:
R2R tool installed ↓

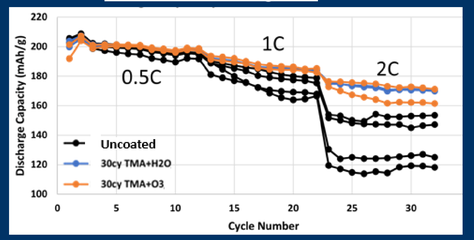


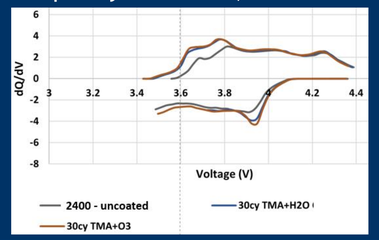
Thermal Stability: % Shrinkage (1hr, MD)
120,135,150 C, uncoated vs.10-200 ALD cycles



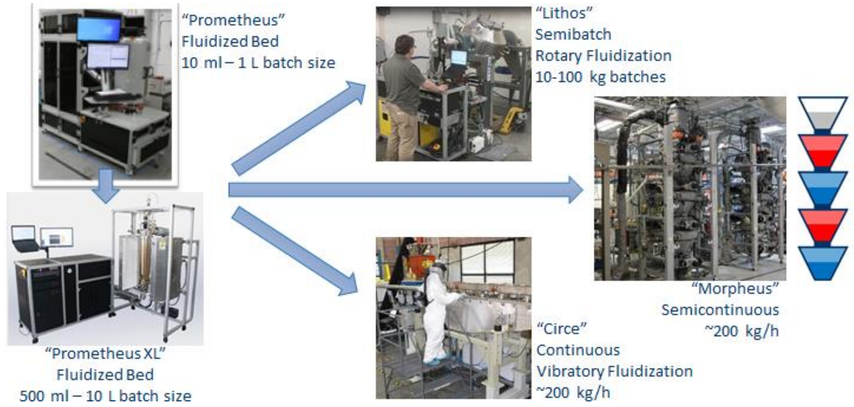
Wetting with Electrolyte:

Rate Test @ high V: ALD minimizes capacity loss at 2C, 4.4 V





FN SCALING: ALD on Powders



ALD Benefits:

- Cathodes: NMC, NCA, LMNO, LCO, Sulfur, etc.
- Anodes: Graphites, Si, composites, Li-metal
- SSB: Electrolytes, LPS, LSPS, etc.
- Additives, components
- Separators web coatings

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