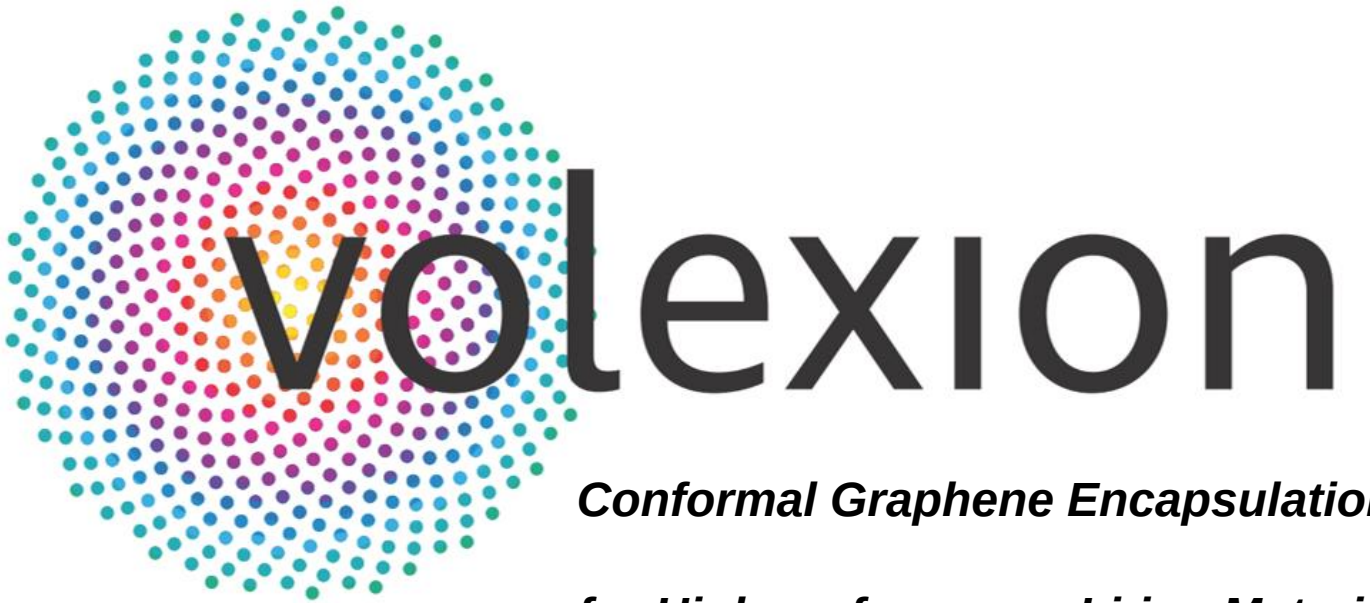

Conformal Graphene Encapsulation

for High performance Li-ion Materials

Damien Despinoy
Chief Executive Officer
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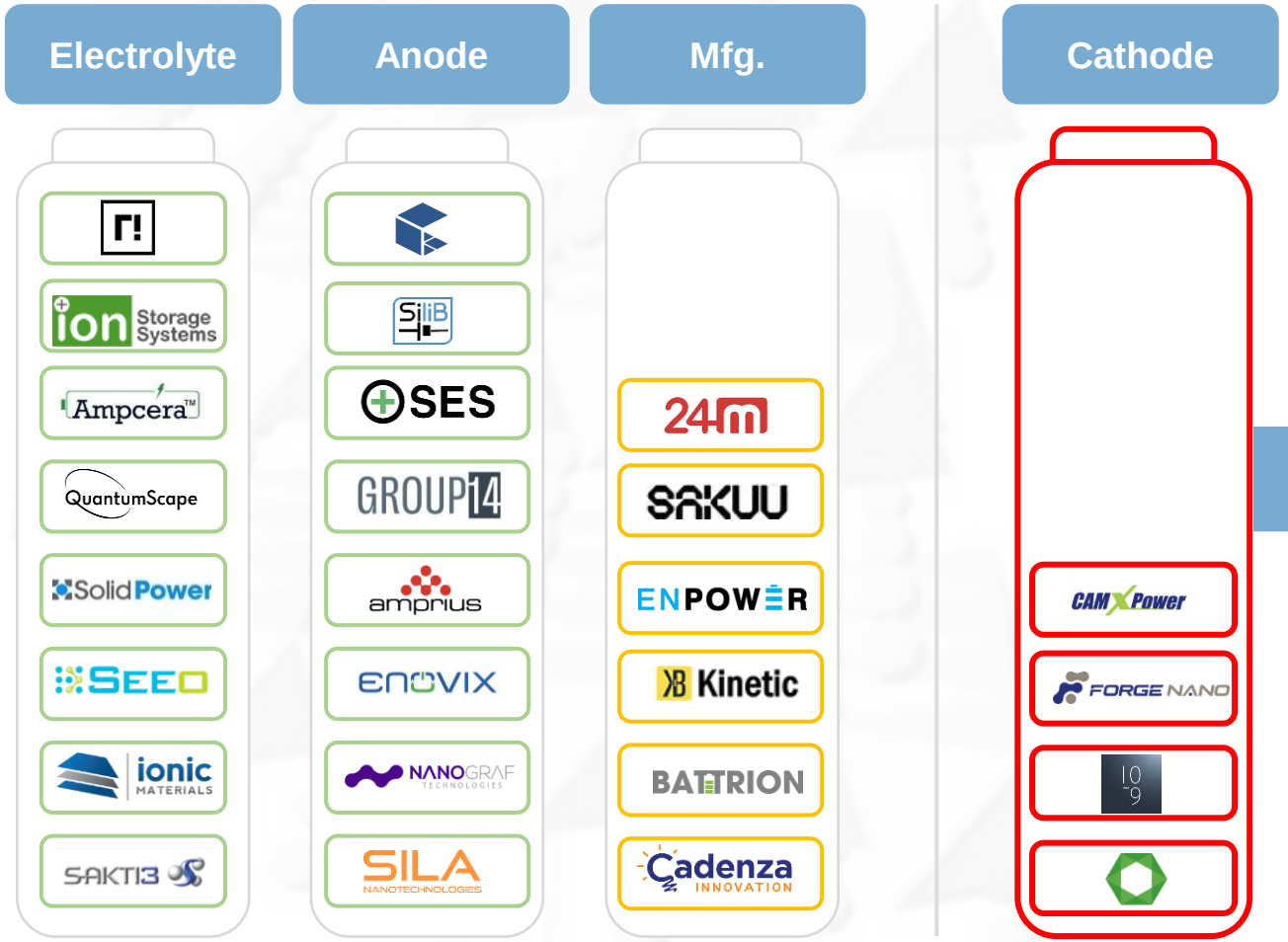
DPEC Presentation
June 5th, 2024

Cathode = Opportunity Space

volexion

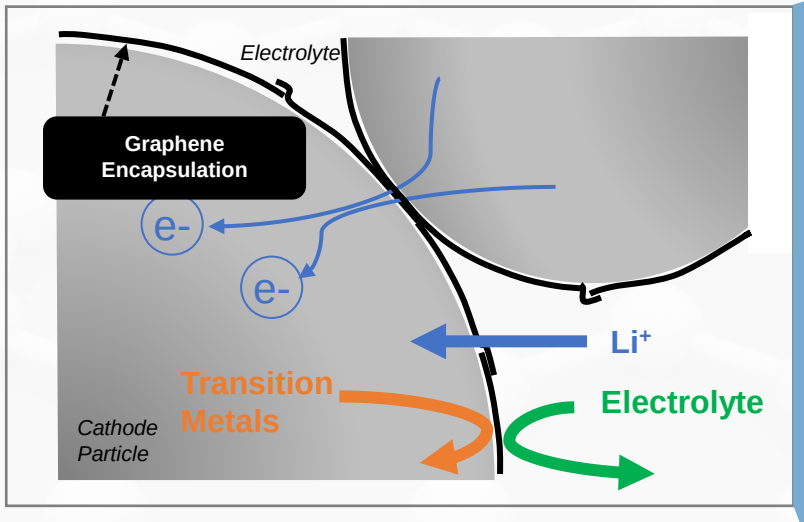


- Highest cost and weight component
- Contains bottleneck metals (Co, Li, Ni)
- Primary driver of cell performance (Energy, Impedance, Safety)
- **Underserved by innovative solutions**

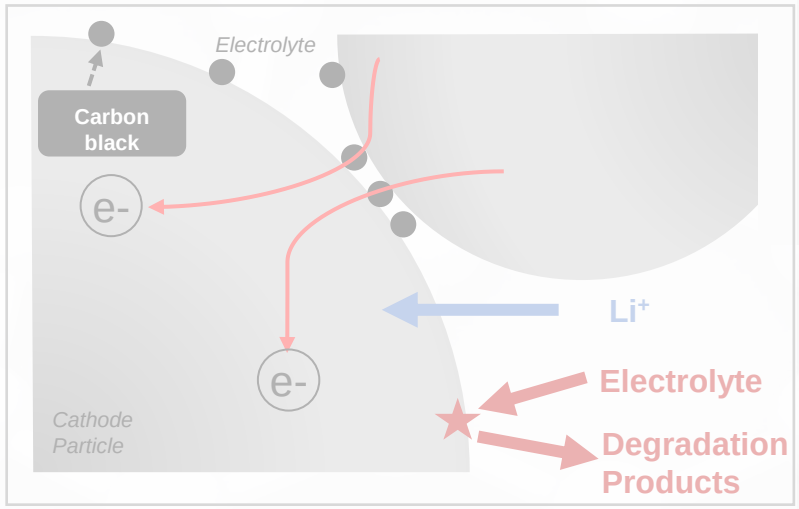
Conformal Graphene Encapsulation for CAM & Beyond

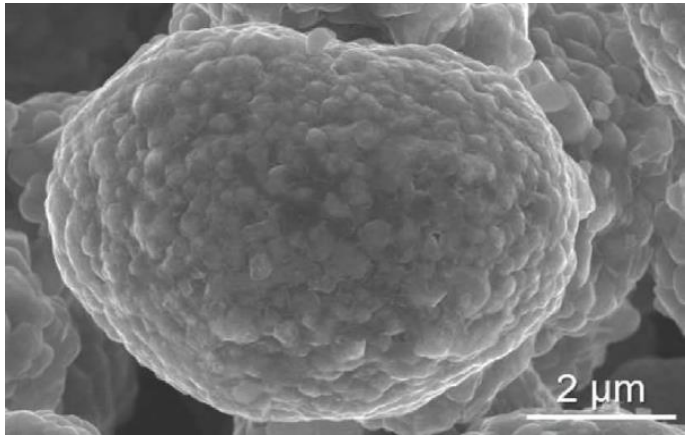
volexion

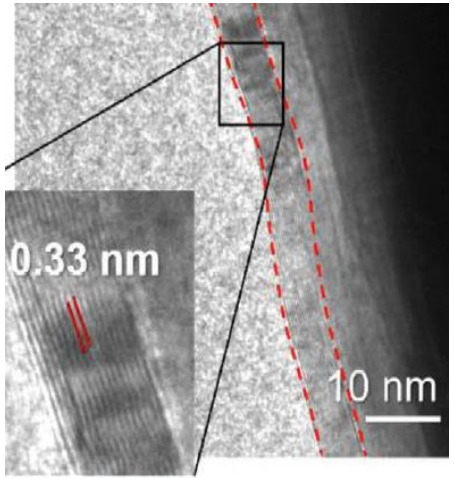
Graphene Encapsulation



Traditional







Conformal, pinhole free, conductive coating

Team & Context

Damien Despinoy
CEO & Co-founder

McKinsey & Company · TotalEnergies · INSEAD

Jonathan Pistorino
CTO

BOSCH · SEEO · ADVANO

Marc Hersam
CSO, Founder

Northwestern University · RAYMOR NanoIntegris

Stakeholders

CLEAN ENERGY VENTURES · earth foundry · CEVG CLEAN ENERGY VENTURE GROUP · E8

Argonne NATIONAL LABORATORY · OBIC · Northwestern | INVO Innovation and New Ventures

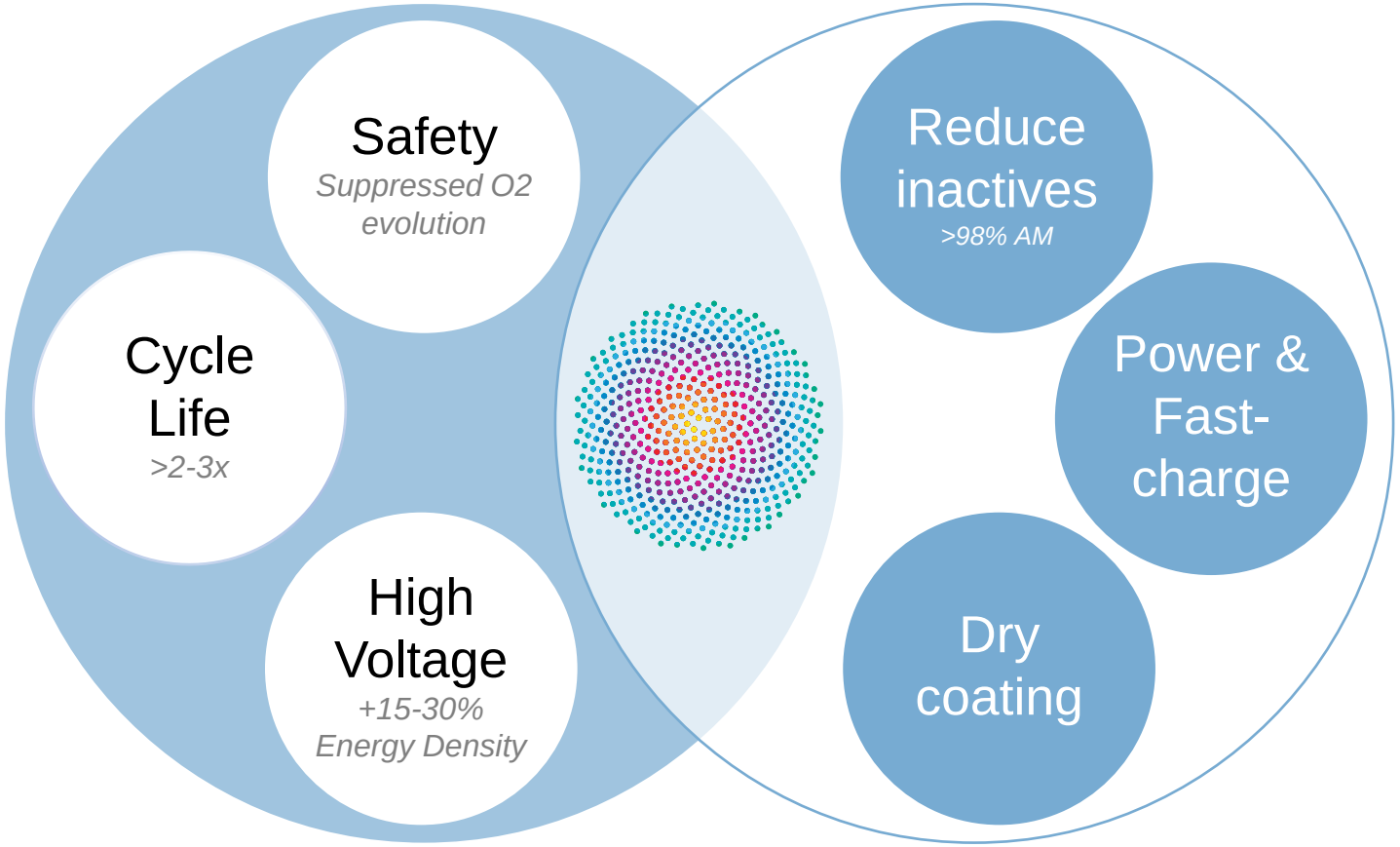
NSF · U.S. Department of Energy · CHAIN REACTION INNOVATIONS · CLEAN TECH OPEN

GAMIC · ScaleFor ClimateTech · VLC Vertical Lift Consortium

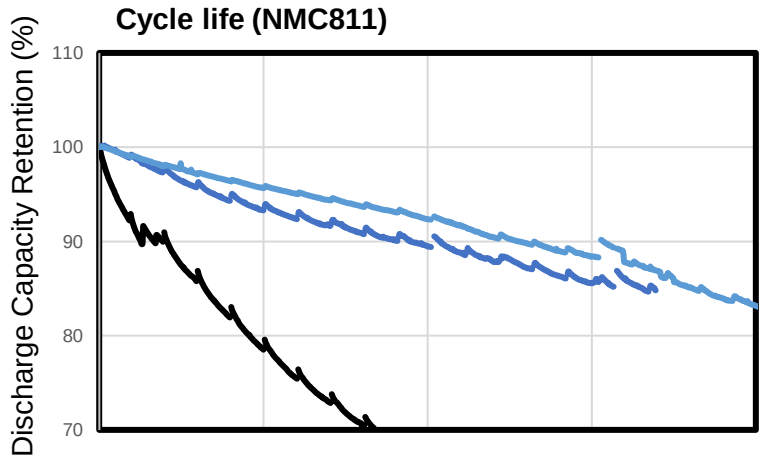
Performance Improvement

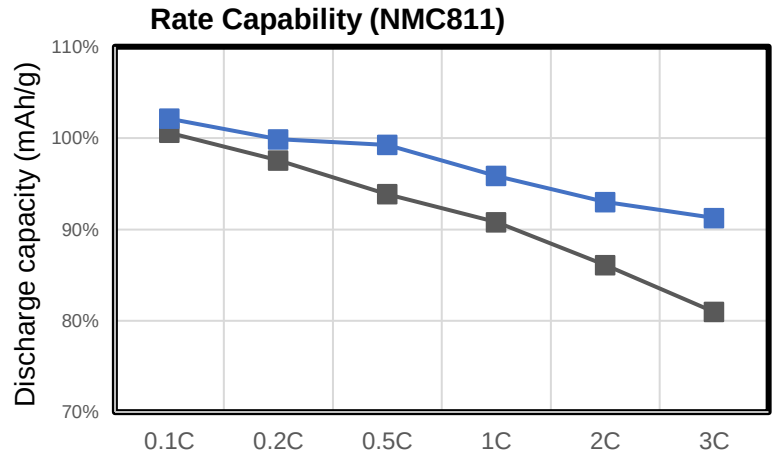
Ni-rich NMC example

Stability ✖ Conductivity



Representative Results

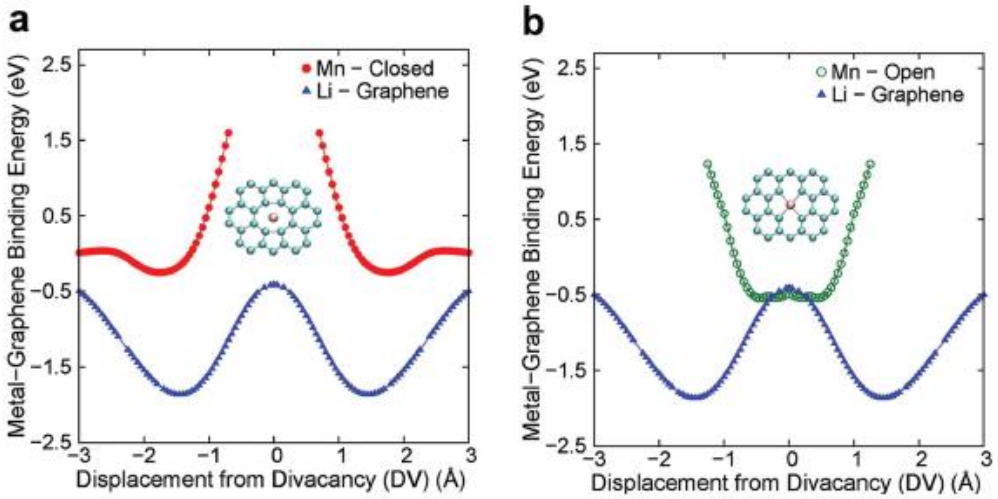




Improvement Mechanisms | Material

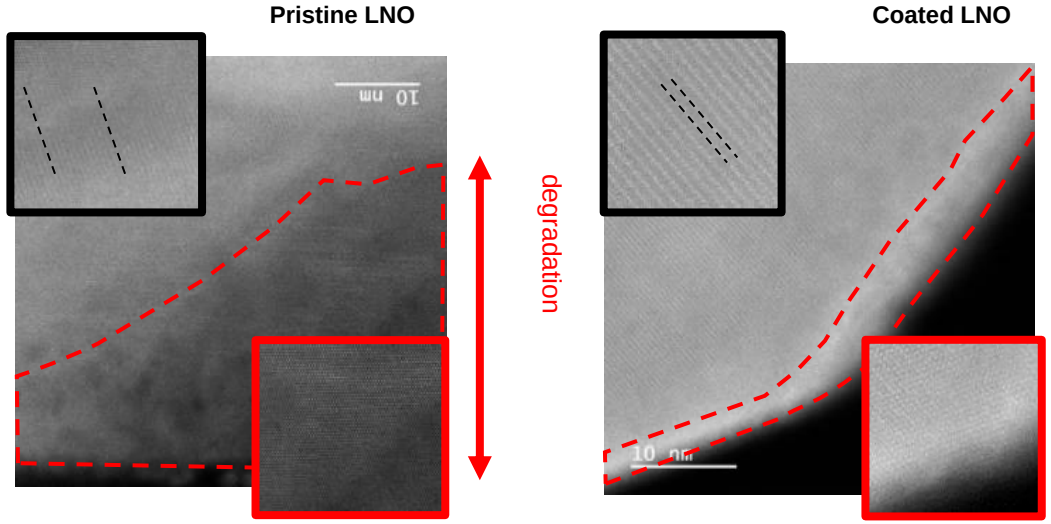
Prevention of transition metal dissolution

- Physical diffusion barrier to ion dissolution and migration into electrolyte
- Suppresses Mn^{3+} disproportionation reaction
- Reduction of Transition Metals migration towards anode



Prevention of phase degradation at surface

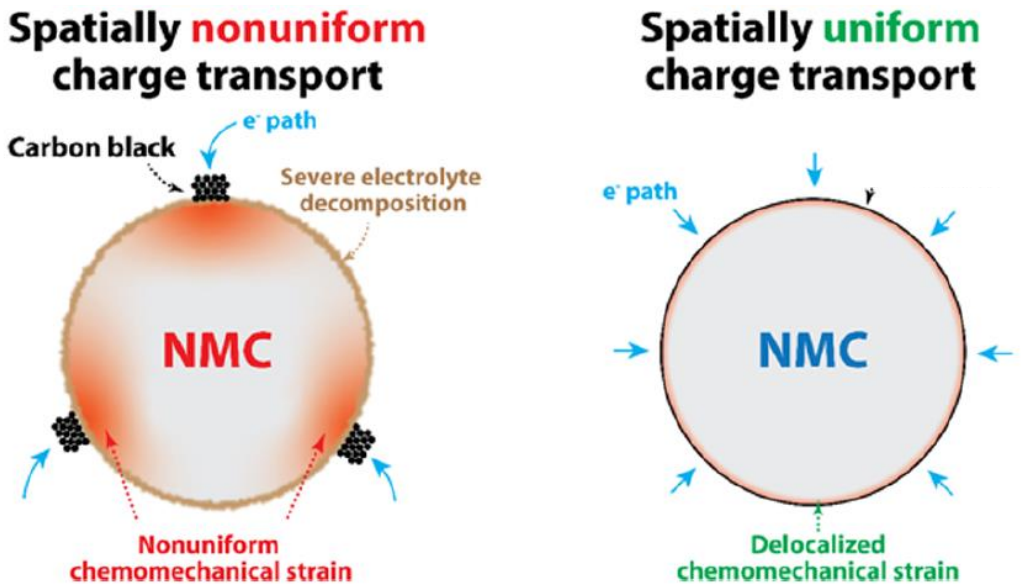
- Minimizes layered → rock salt transformation at the surface of Ni-rich cathode materials during cycling
- Suppressed O_2 evolution



Improvement Mechanisms | Material

Reduced Chemo mechanical strains

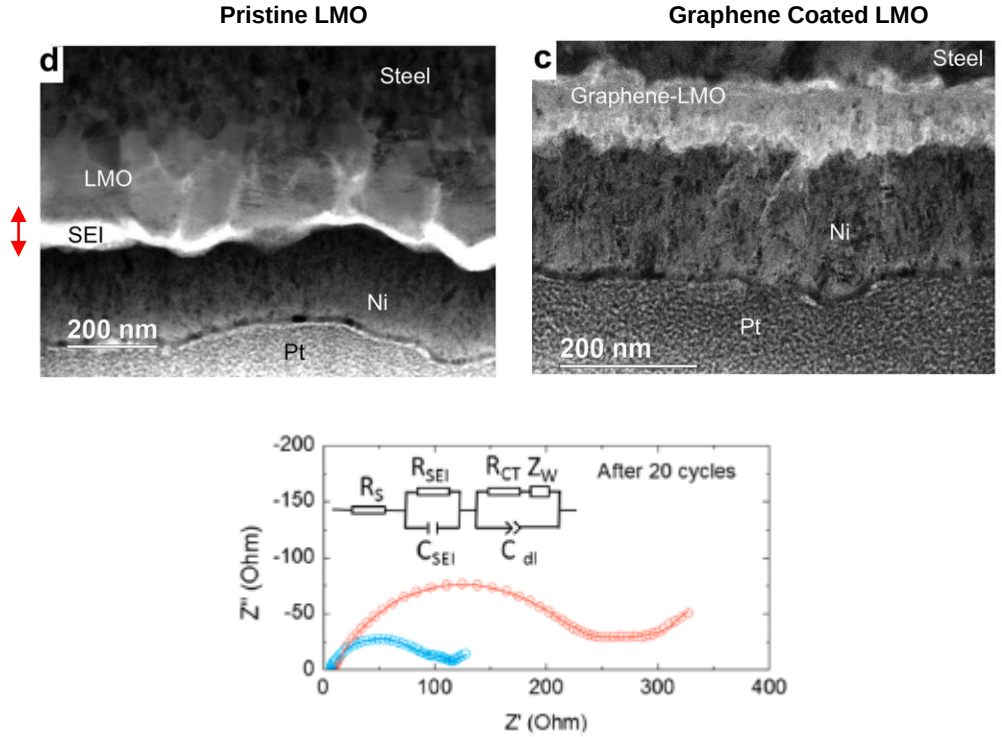
- Non-uniform Chemo-Mechanical strain -> Particle cracking
- Graphene coating distributes electronic/Lithium diffusion, reducing particle fracture



Improvement Mechanisms | Electrochemical

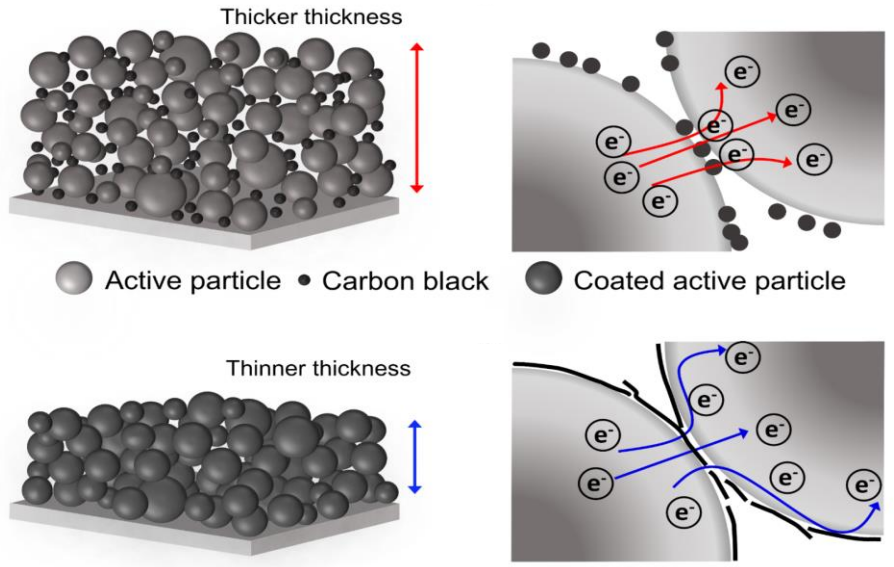
Stabilization of Solid Electrolyte Interphase

- Thinner & Denser Cathodic Electrolyte Interface (CEI) by providing well-defined physical barrier against electrolyte decomposition



Reduced Inactive Materials

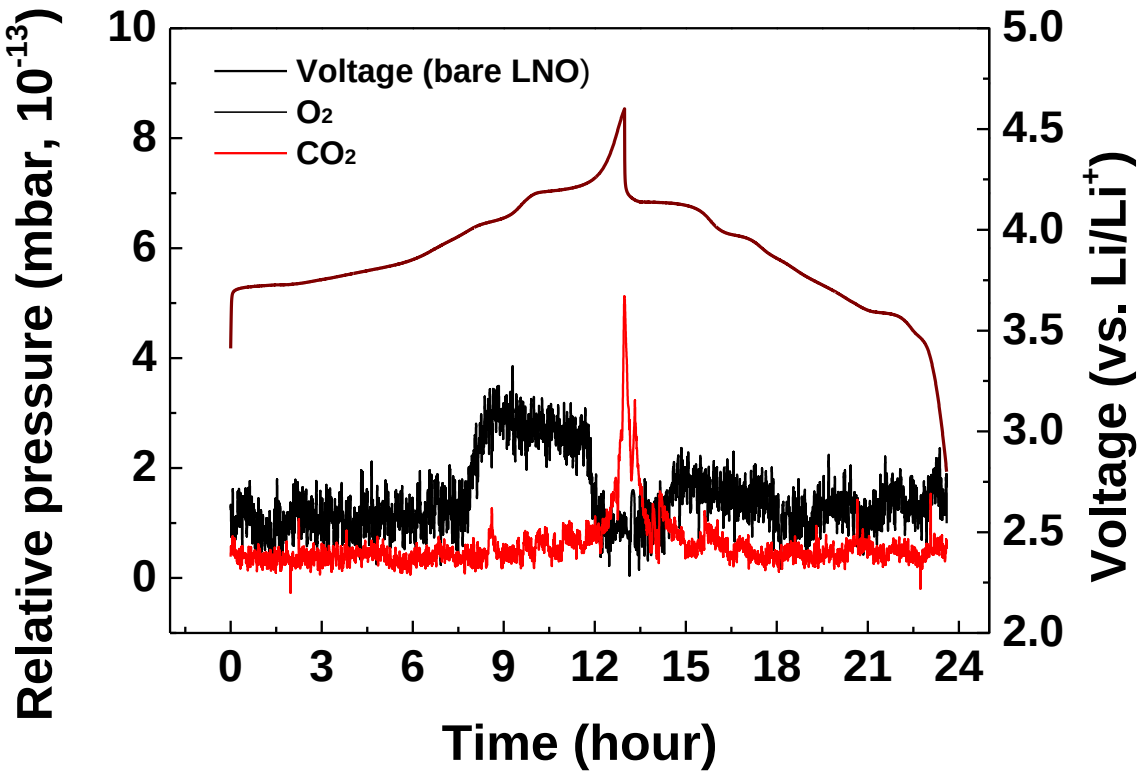
- Increasing AM content to >98%
- Enabling increased electrode density
- Enabling high areal density electrodes



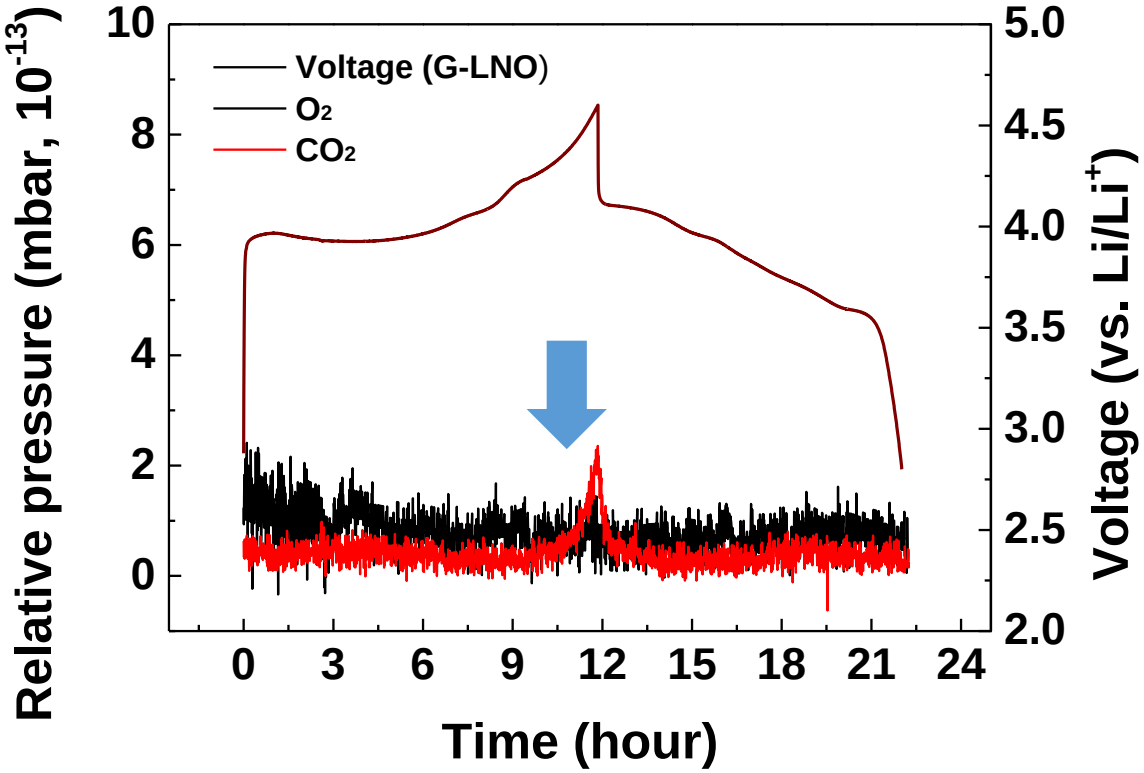
Safety | Gassing Reduction

LNO

Bare LNO



Graphene-encapsulated LNO



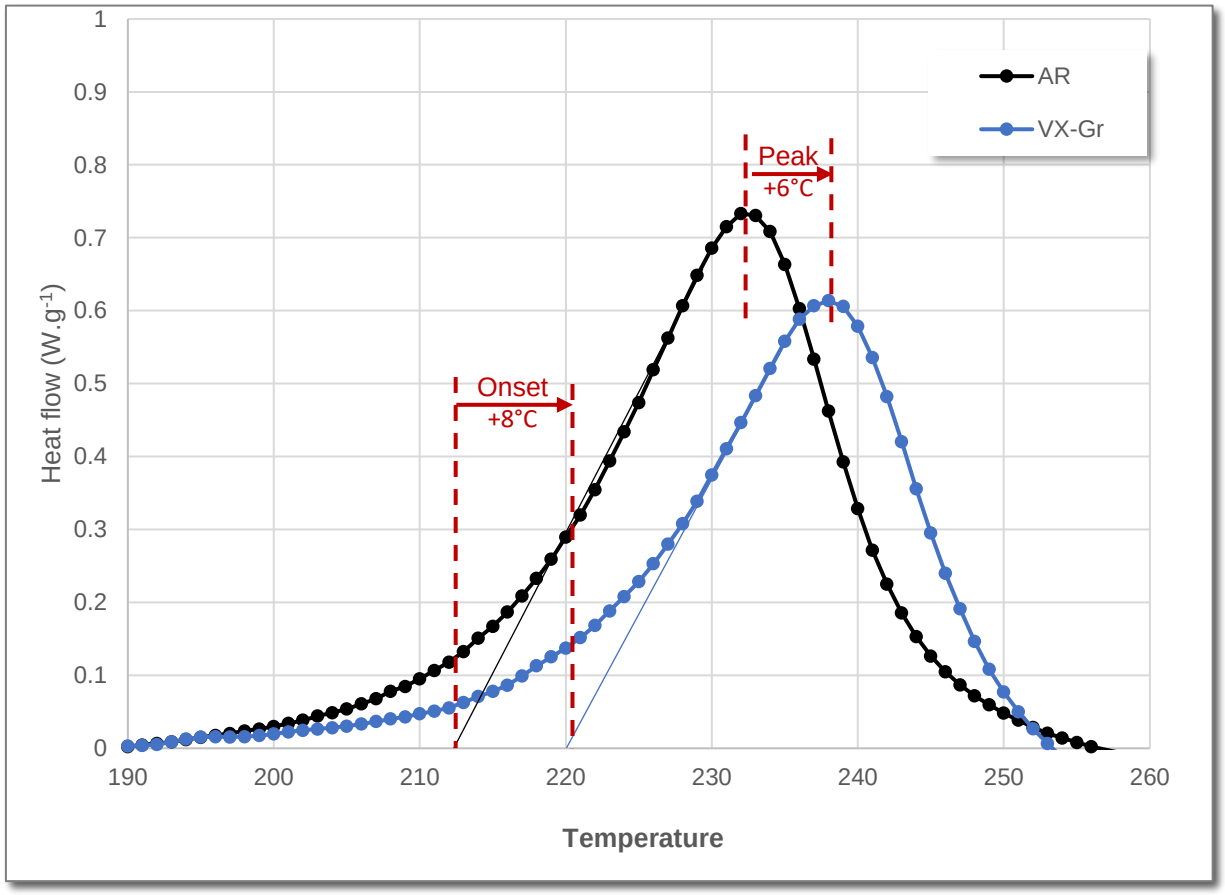
- **In-situ Differential Electrochemical Mass Spectroscopy**
- **Graphene coating mitigates the oxygen gas evolution**

SOURCE: Park et al...Hersam_Elucidating and Mitigating High-Voltage Degradation Cascades in Cobalt Free LNO_Adv Mat_2022

Safety | DSC

NMC811

DSC test | Commercial NMC811



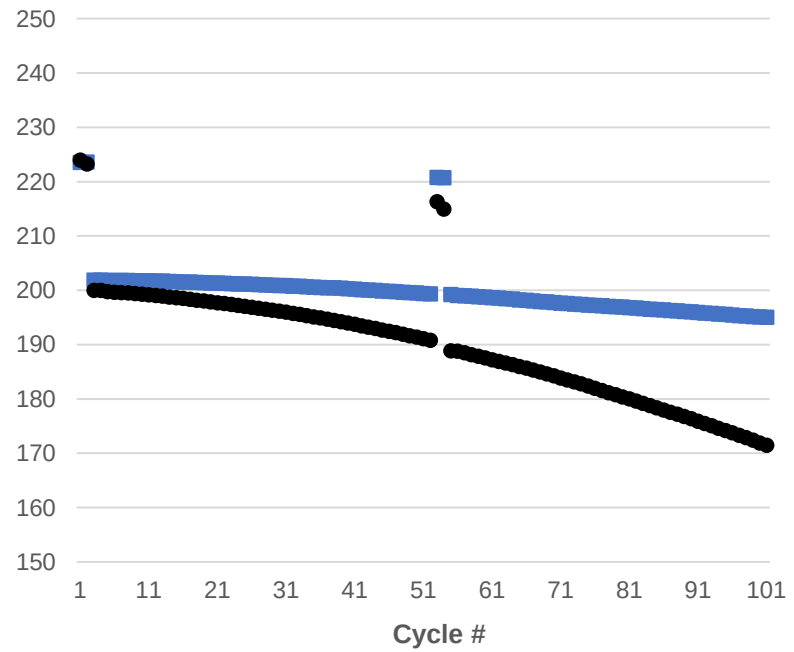
- VX-Gr encapsulation improves thermal performance of Ni-rich materials
  - Onset & peak temperature shifted by 8°C and 6°C, respectively
  - Heat release reduced by 20%+
- Improved thermal performance linked to suppressed O_2 evolution thanks to the graphene encapsulation

Half-cell stability

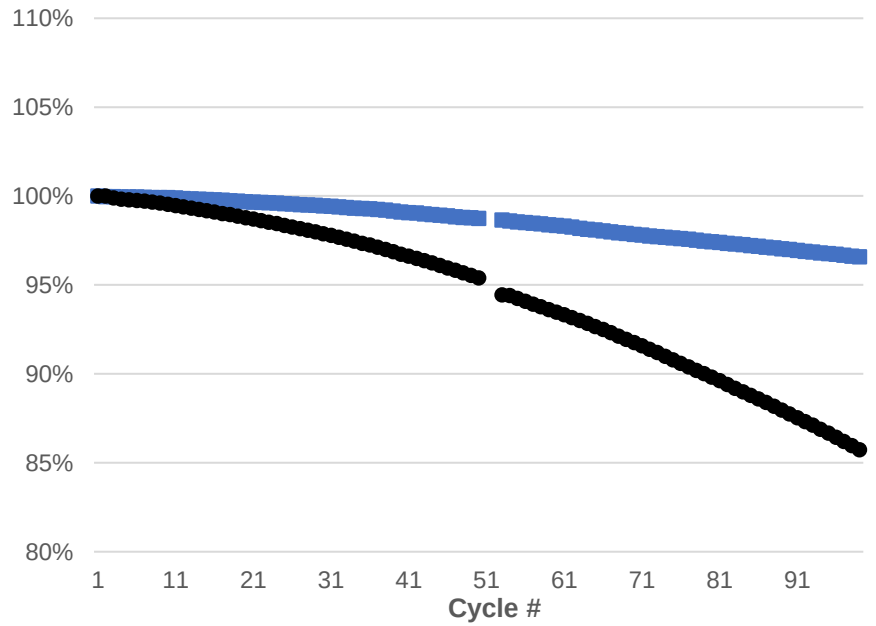
NMC9.5.5 | Regular Voltage

VX-Gr | Volexion (Avg of 3)
Baseline | Volexion (Avg of 2)
Baseline | 3rd party (Avg of 2)

Discharge capacity (mAh.g^{-1})



Capacity Retention (%)



Significant stabilization observed on coin cells with Gen4.1 process

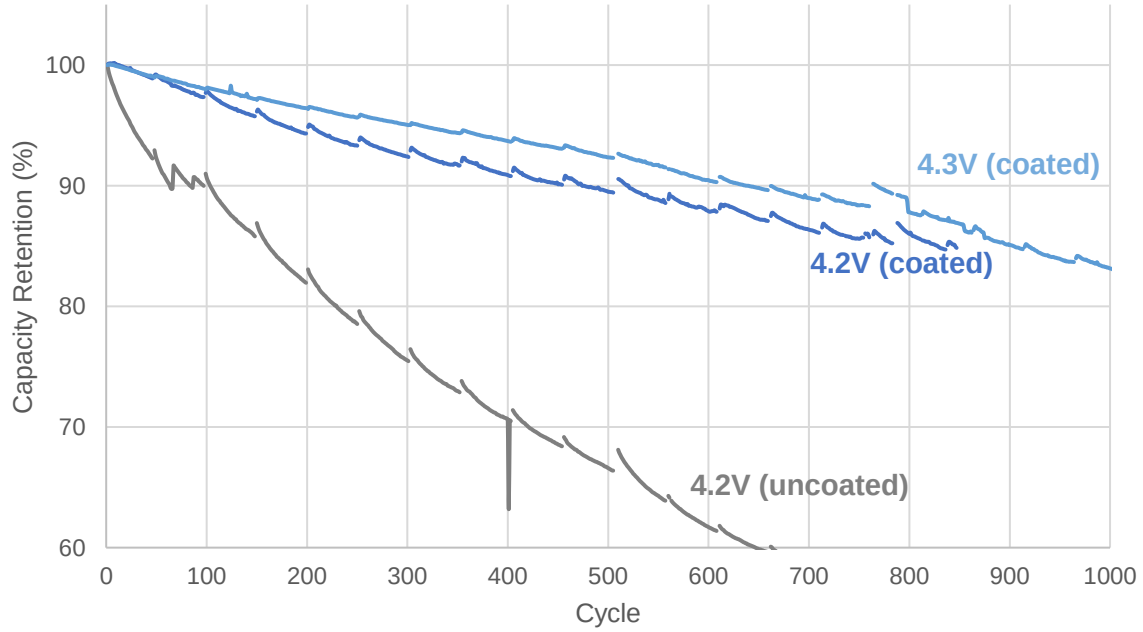
- **Gr-Encapsulated material retains >96% capacity after 100 cycles vs. 78-86% for As-Received[1]**
- **No loss in initial capacity nor rate capability observed**

1 As-Received Material comes pre-treated with State of the Art coatings by CAM Manufacturer
2 Conductive Additive include Volexion Additive and Carbon Black

Pouch Cell Capacity Retention

NMC811 | Regular & High V

Capacity retention – Pouch cells

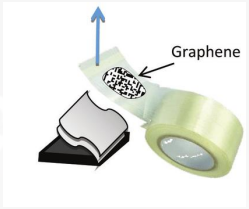
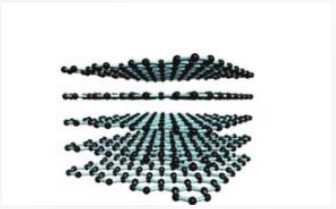
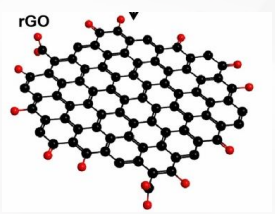


VX-Gr
As-Received

- **Single-Layer Pouch cell**
- **>3x cycle life improvement**
  - ~1000 cycles for coated cathode material vs. <300 cycles for uncoated material
  - Capacity fading not degraded by increasing voltage

Striking a balance between cost and performance

Graphene Manufacturing Cost / Performance

	CVD[1]	Exfoliation + Surfactant	GO / rGO[1]
			
Cost	High	Low	Low
Performance	High	High	Medium

Volexion's approach

- Graphene has been dubbed the **wonder material** thanks to superior **mechanical, electrical, thermal** properties
- Scaling-up graphene without compromising properties has proven to be a challenge
- Volexion's approach strikes the right balance between graphene quality and cost / scalability

1 Chemical Vapor Deposition; reduced Graphene Oxide
SOURCE: Volexion's proprietary research

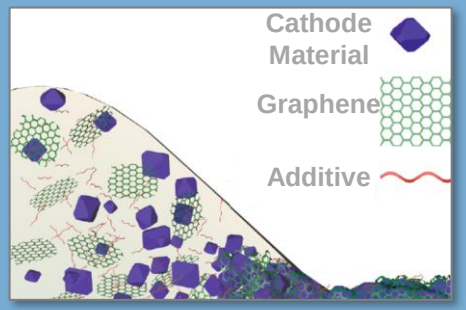
Scalable, Drop-in Solution

1. Graphene precursor

Graphite + Additive
Solution-based process

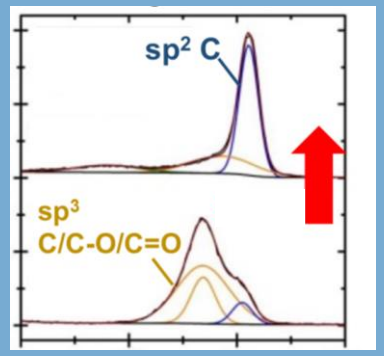
2a. Encapsulation

Benign process conditions,
Solution–based



2b. LowT Heat treatment

Additive converts to sp2-C



Manufacturing Drop-in

Scalable & Modular

Chemistry Agnostic
(NMC, Mn-rich, L[M]FP)

Form Factor Agnostic

Partnerships focused

Flexible GTM

- ❑ Gr-Precursor
- ❑ Encapsulation
- ❑ CAM Mfg.
- ❑ Cell Mfg.
- ❑ Licensing

Broad partner spectrum

Cathode Suppliers

Cell Suppliers

OEMs

Approach

Current focus

- ❑ Scale-up & validation through partnerships
- ❑ In progress
  - ❑ 4 evaluations
  - ❑ Multiple early conversations
- ❑ Exclusive license
- ❑ 12 patents, 3 families, 5 geographies
- ❑ Deep library available

Roadmap & Timeline

volexion

Prior years

Solution Development

- Designed & Optimized Graphene Precursor and encapsulation process

2024-2025

Scale-up

- Scaling-up processes to achieve 10kg batch size

~20 T/yr capable

2026

Commercial

- Specialty Applications

>1,000 T/yr

2028

Commercial

- EVs

>10,000T/yr

Next steps

Get in Touch

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damien.despinoy@volexion-inc.com