

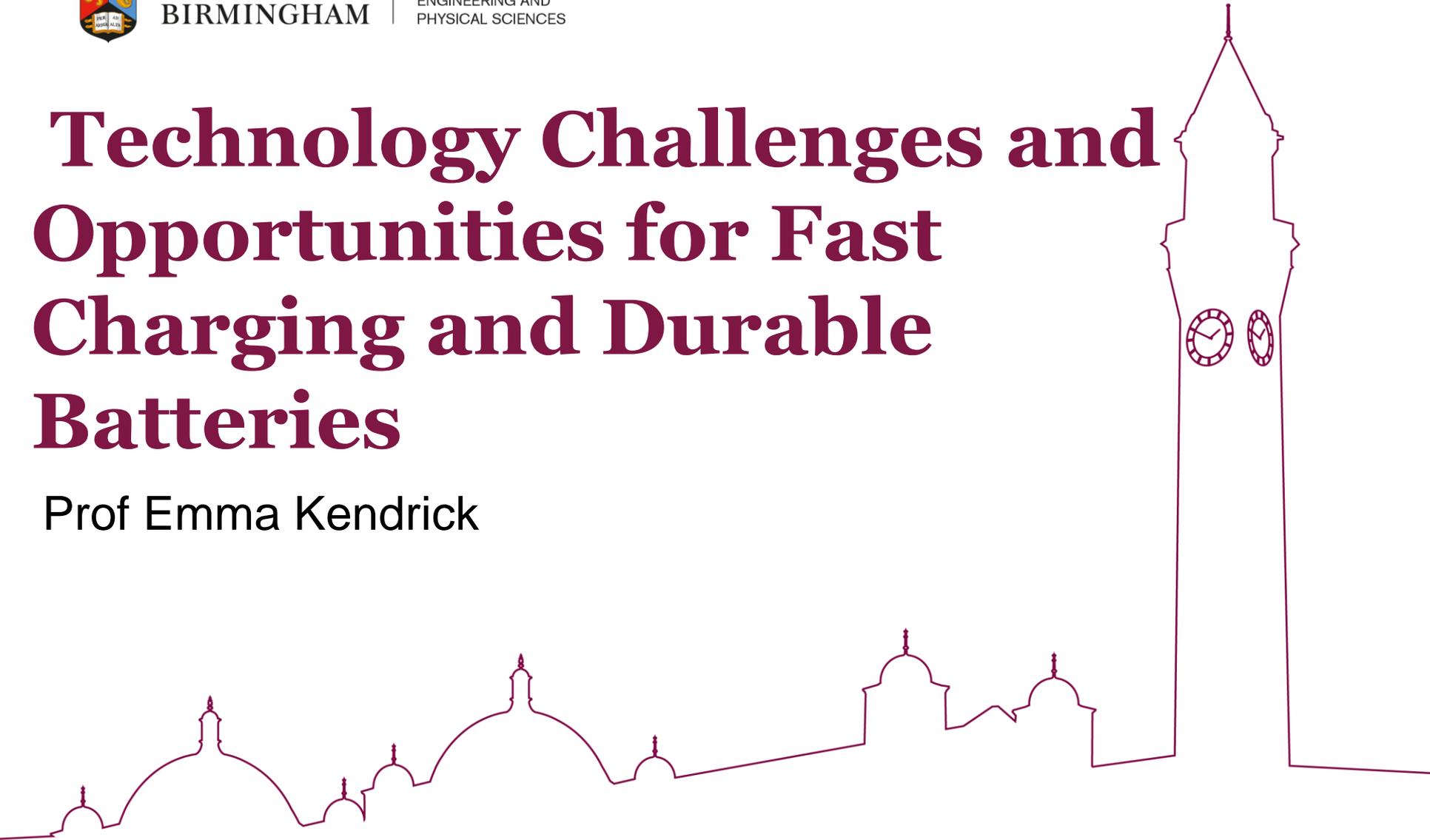


UNIVERSITY OF
BIRMINGHAM

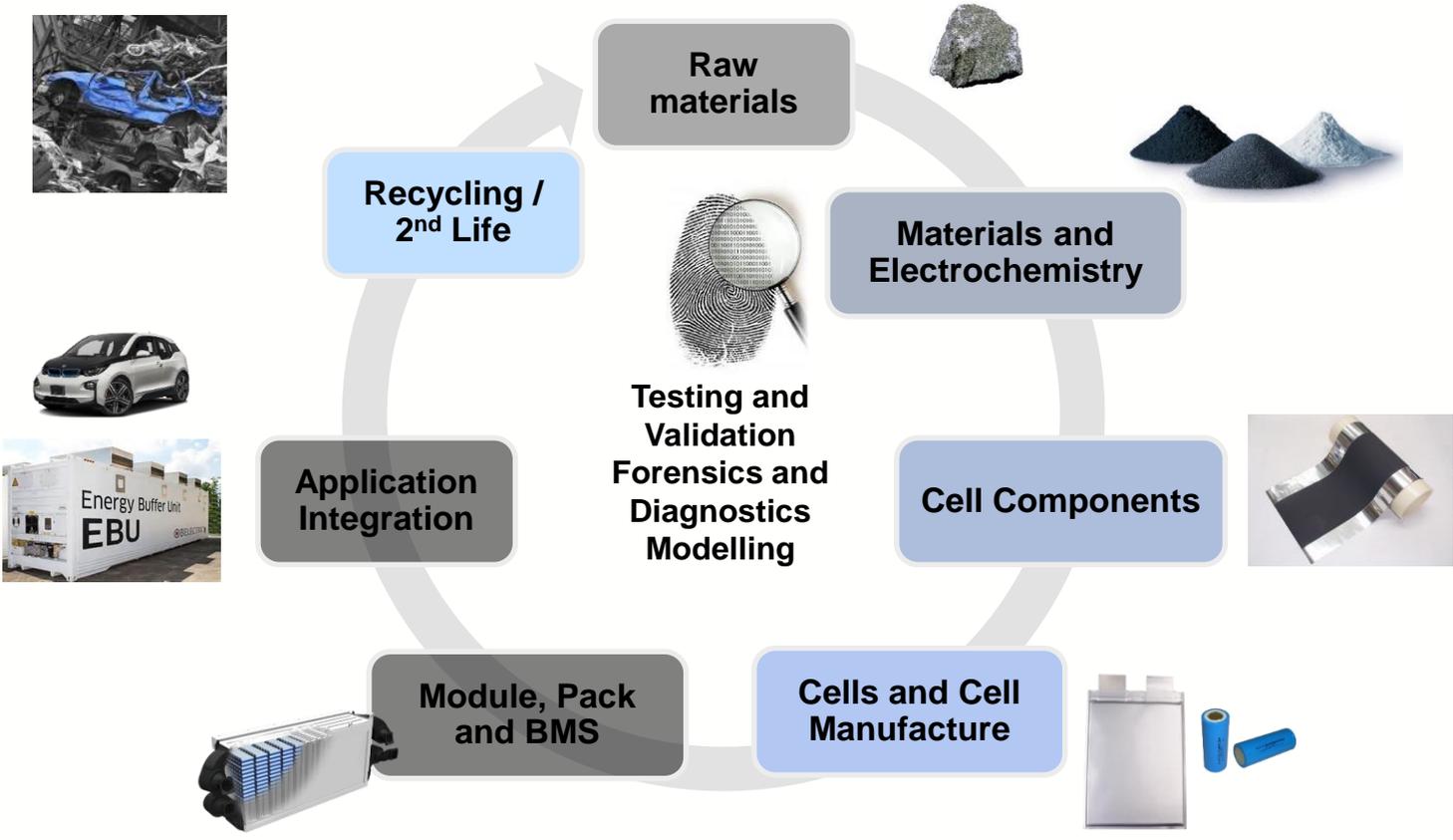
COLLEGE OF
ENGINEERING AND
PHYSICAL SCIENCES

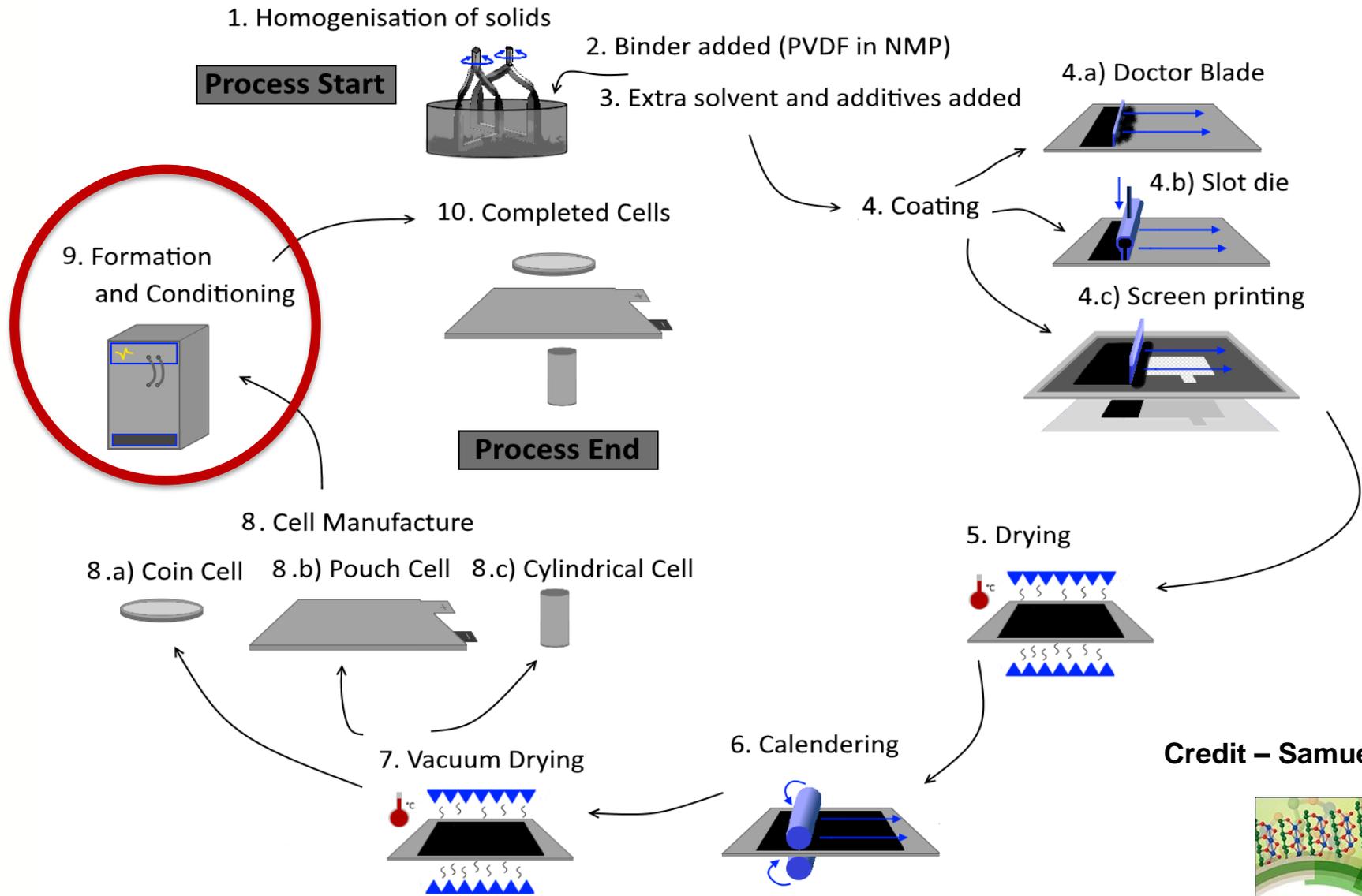
Technology Challenges and Opportunities for Fast Charging and Durable Batteries

Prof Emma Kendrick

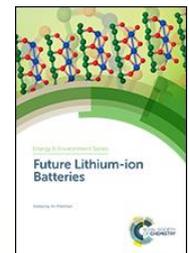


Integrated - Energy Storage Research 'Circular Economy'





Credit – Samuel Roberts



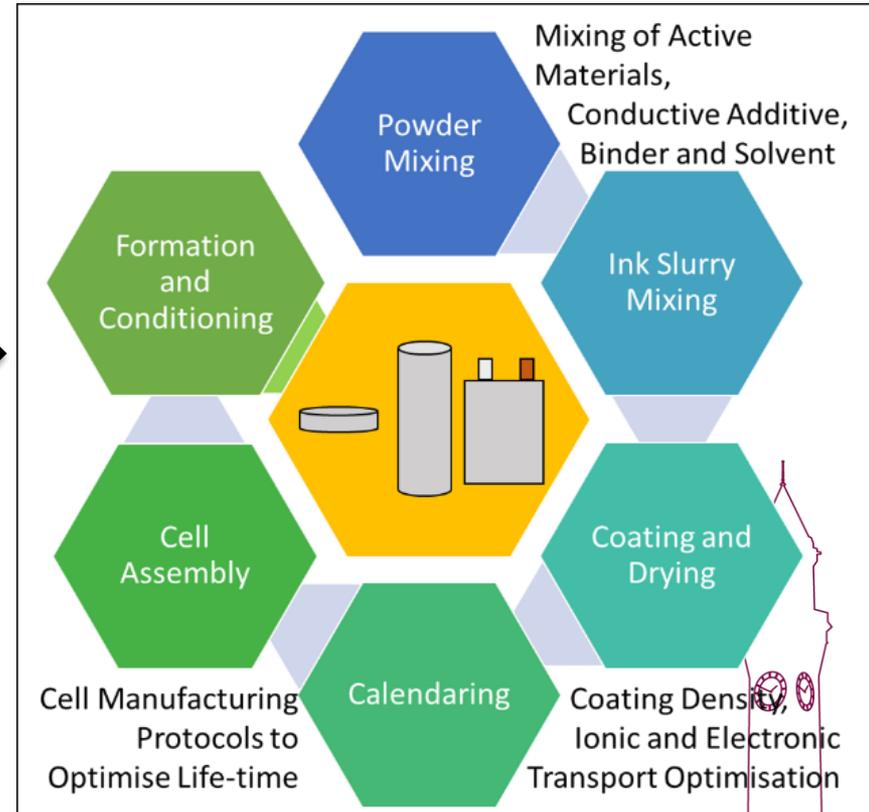
Book: Future Lithium ion batteries. Chapter 11, Emma Kendrick 'Advanced Manufacturing' April 2019. <https://doi.org/10.1039/9781788016124-00262>

Battery Properties for Optimisation

- Cycle Life / Calendar Life
- Cost
- Energy / Power
- Safety

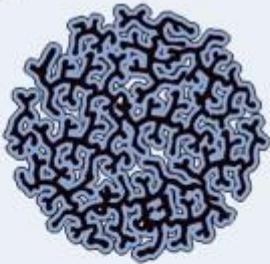
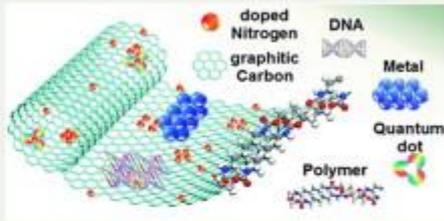
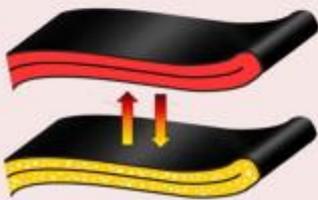


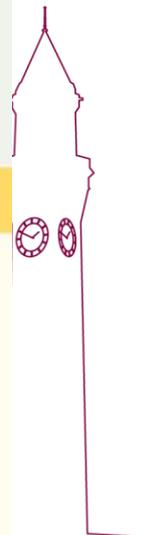
Manufacturing Processes



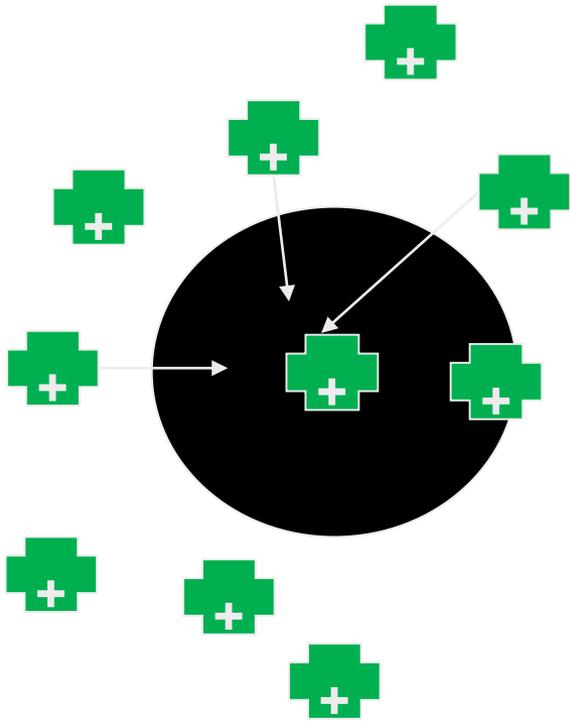
Material Design Principals - 1

□ Power is Current X Voltage = Watts

(a) Dimension Reduction	(b) Composite Formation	(c) Doping & Functionalization
<ul style="list-style-type: none"> • Faster ion & electron transport • Higher surface reactivity • Relief of stress(s) & improved mechanical stability 	<ul style="list-style-type: none"> • Conductive media • Mechanical (structural) support 	<ul style="list-style-type: none"> • Faster ion & electron transport • Improved chemical & thermal stability 
(d) Morphology Control	(e) Coating & Encapsulation	(f) Electrolyte Modification
<ul style="list-style-type: none"> • Improved structural stability • Faster ion, electron, & phonon transport • Modified reactivity 	<ul style="list-style-type: none"> • Protection from electrolyte • Prevention of electrolyte decomposition • Stabilization of surface reactions • Conductive media 	<ul style="list-style-type: none"> • Formation of passivation layer(s) on the surface of electrode(s) • Controlled solubility of active material(s) & decomposition product(s) 

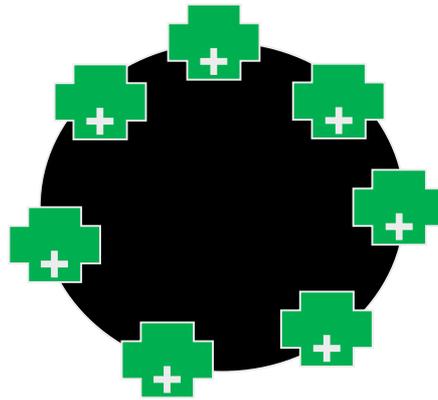


Electrolyte

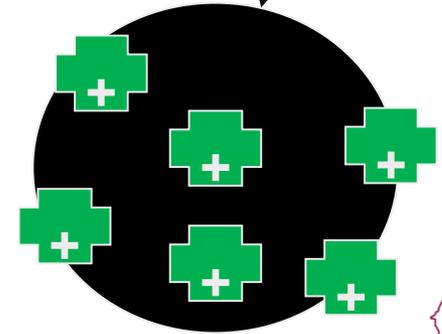


Low Rate and
Equilibrium

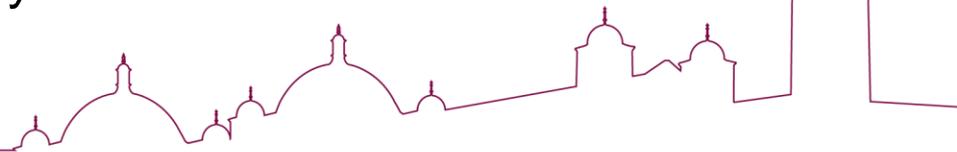
Voltage Cut-off reached too Fast



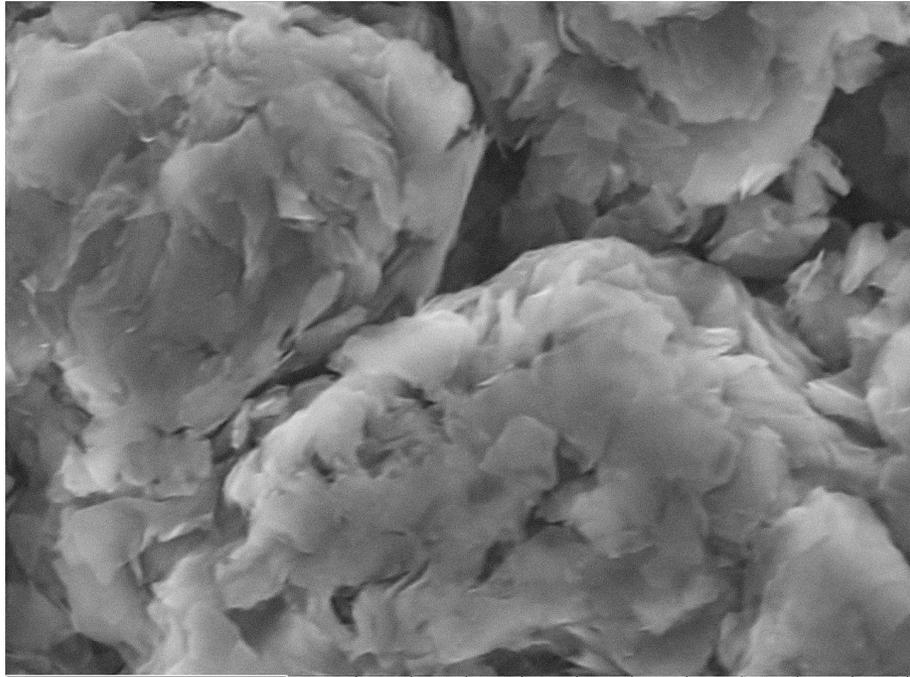
Surface super
concentrated
Voltage reached
early



Electrolyte
Depletion

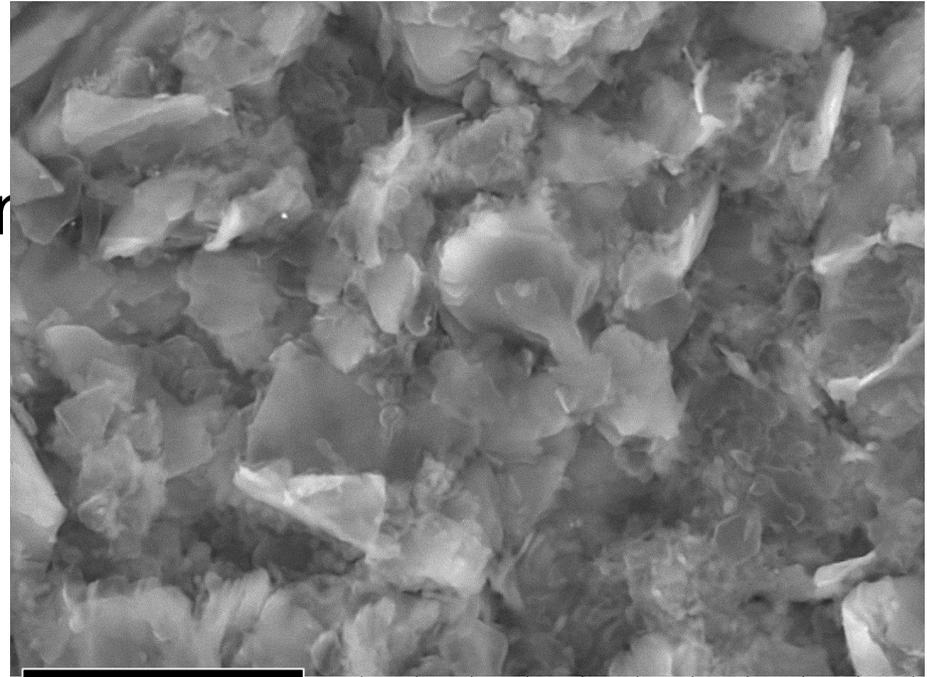


Anode : Graphite after pulsing



2019/04/01 NL MD13.5 x5.0k 20 ?m

Original electrode



2019/05/17 NMMD8.4 x5.0k 20 ?m

After 5000 pulse sequences



Anode : Dendrites

EL-CELL[®]
electrochemical test equipment



**Visualizing lithium dendrite growth
in a graphite vs lithium metal cell**



Opportunities in Materials and Cell Designs of High Power

- Active Materials development
 - Higher ionic and electronic conductivities
 - Smaller Particle Sizes, Hierarchical Particles
- Electrode Designs for Fast Ionic Transport
 - Higher electronic and ionic conductivities
 - Reduced Impedance
- Electrolyte
 - Improved Wettability of electrode
 - Faster ionic Conductivity
- Separator
 - Thinner and lower resistance separators

