

Lithium-Ion Battery: Overview



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Who We Are

Exponent is a multi-disciplinary engineering and scientific consulting firm that brings together more than 90 different disciplines to solve important engineering, science, and regulatory issues facing our clients

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Battery Basics



Battery Basics – The “Bucket” Analogy

Consider the two buckets to the left:

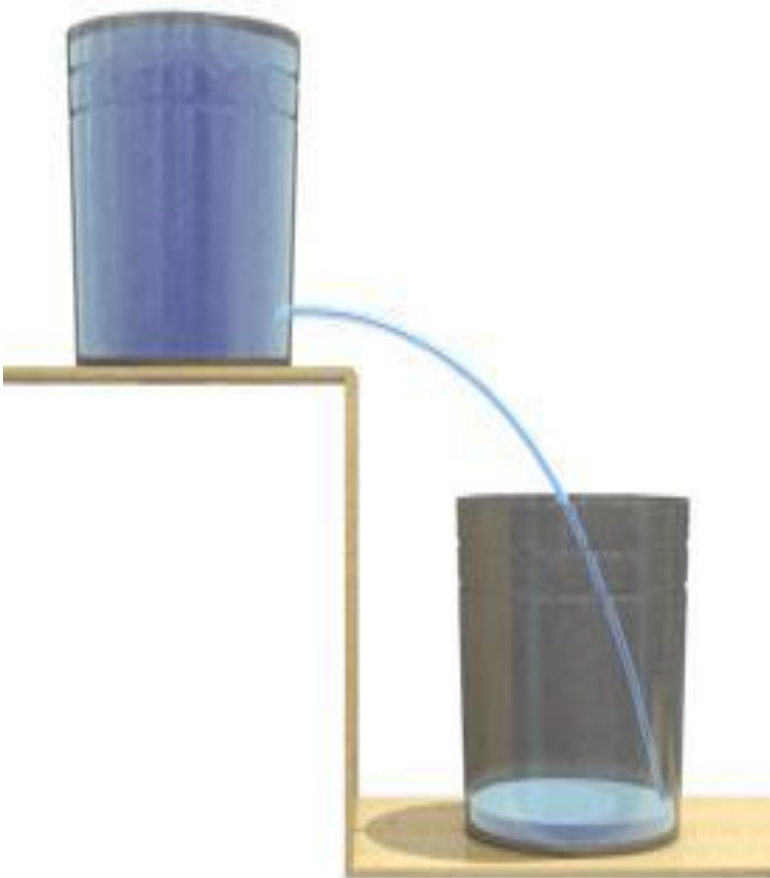
- If the elevated bucket of water is poured into the lower empty bucket, we can generate energy (e.g. turning a water wheel, running an electric generator, etc...)



Battery Basics – The “Bucket” Analogy

Consider the two buckets to the left:

- If the elevated bucket of water is poured into the lower empty bucket, we can generate energy (e.g. turning a water wheel, running an electric generator, etc...)
- The amount of ENERGY we can generate is related to:
 - the amount of water in the top bucket, i.e. the CAPACITY of the bucket
 - the difference in the height of the two buckets, which determines the POTENTIAL energy of the system
- The amount of POWER available is related to the size of the hole that allows the water to flow from the top bucket to the bottom bucket





- Similar to the buckets, batteries are energy storage systems, and therefore have the same fundamental performance attributes:

- Capacity
- Potential (i.e. Voltage)
- Power

Terminology



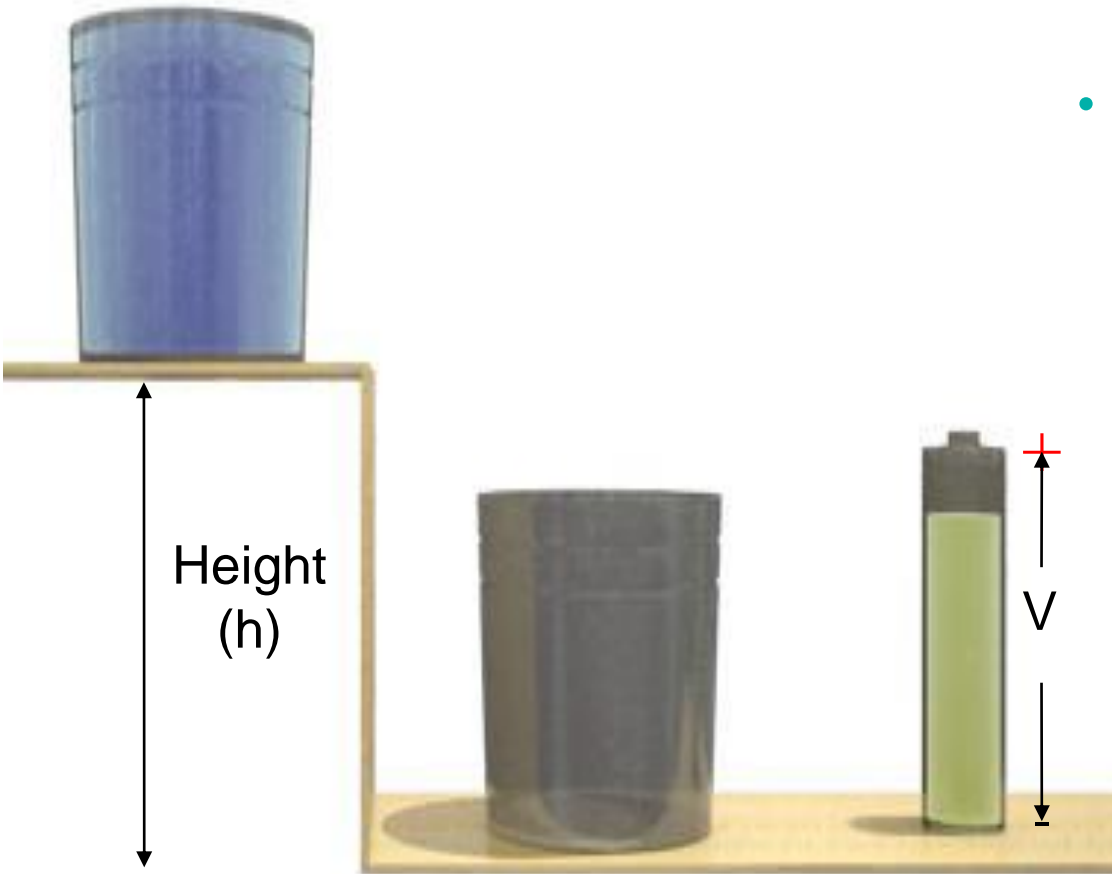
Gravitational
Mass (m)

Capacity
(Ah)



- **Capacity**
 - Amount of electrical charge a battery can deliver
 - Units: ampere-hour (Ah)
 - Typical AA alkaline: 3 Ah
 - Typical car starter battery: 80 Ah

Terminology



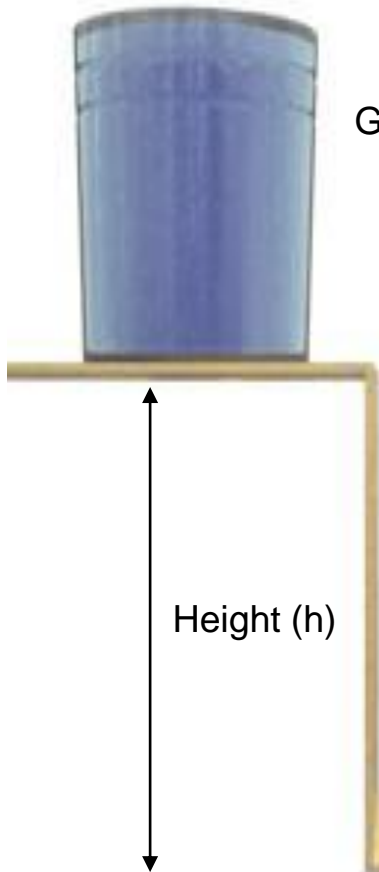
- **Voltage**

- Thermodynamic measure of chemical potential stored in the cell
- Units: Volts (V)
- Typical AA alkaline: 1.67 V (fully charged)
- Typical lithium-ion cell: 4.2 V (fully charged)

Terminology

$$E = h \times m$$

Gravitational
Mass (m)

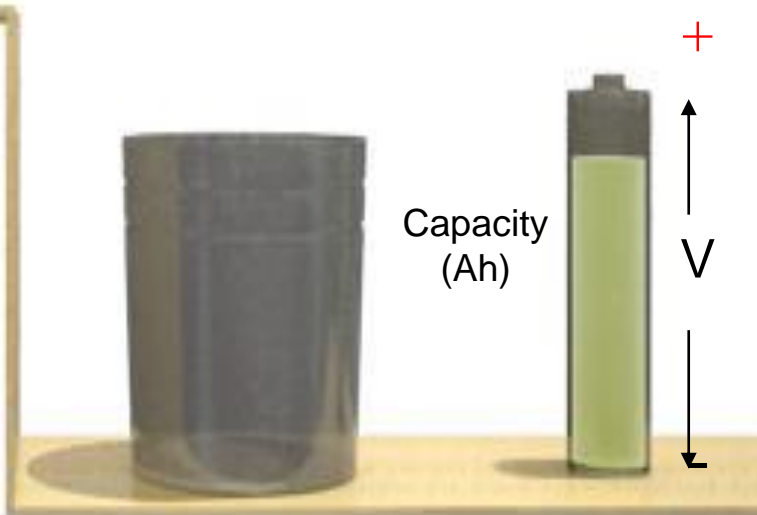


$$E = C \times V$$

Capacity
(Ah)

+

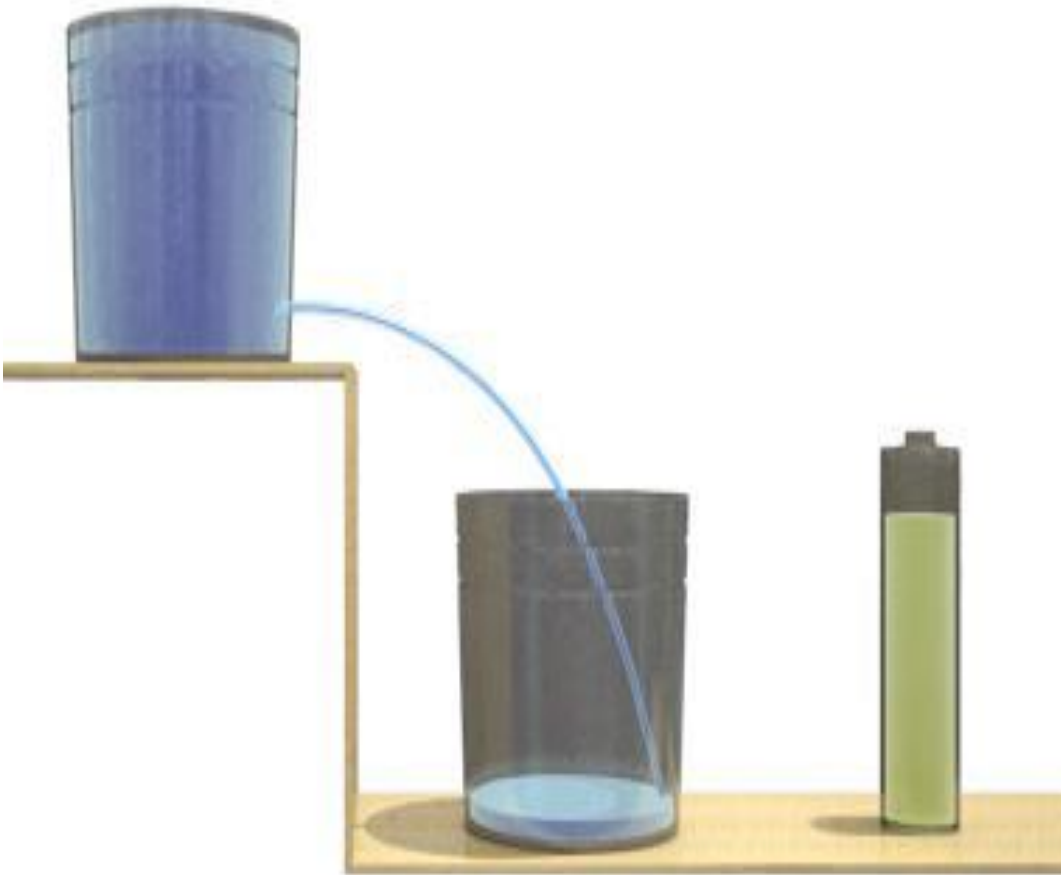
V



- **Energy:**

- capacity x voltage
- Units: Watt-hours (Wh)
- Other common units include Joules, calories and BTUs
- Typical AA alkaline: 3.6 Wh

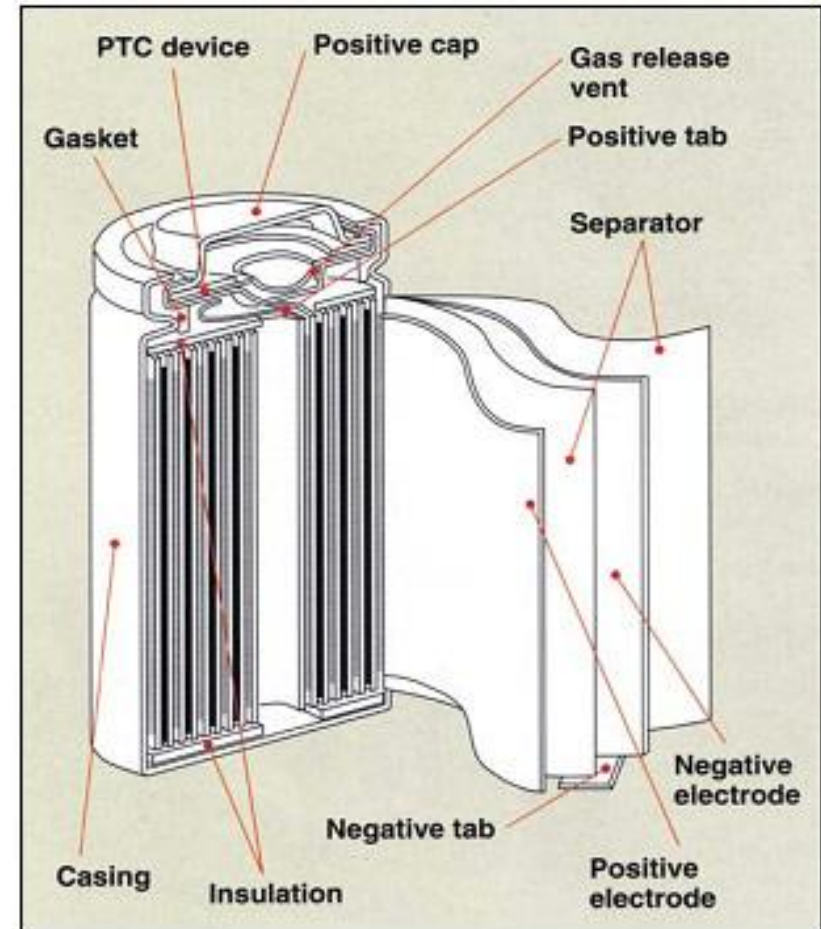
Terminology

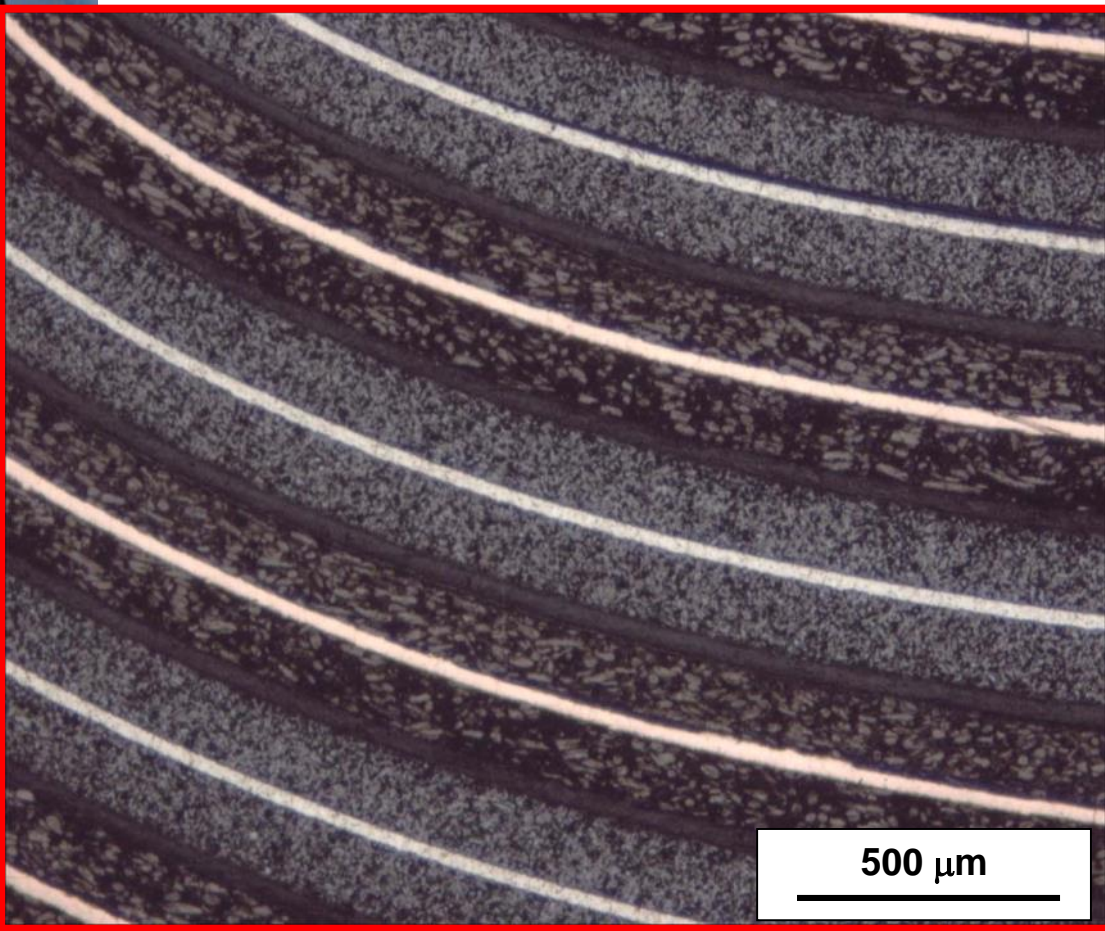
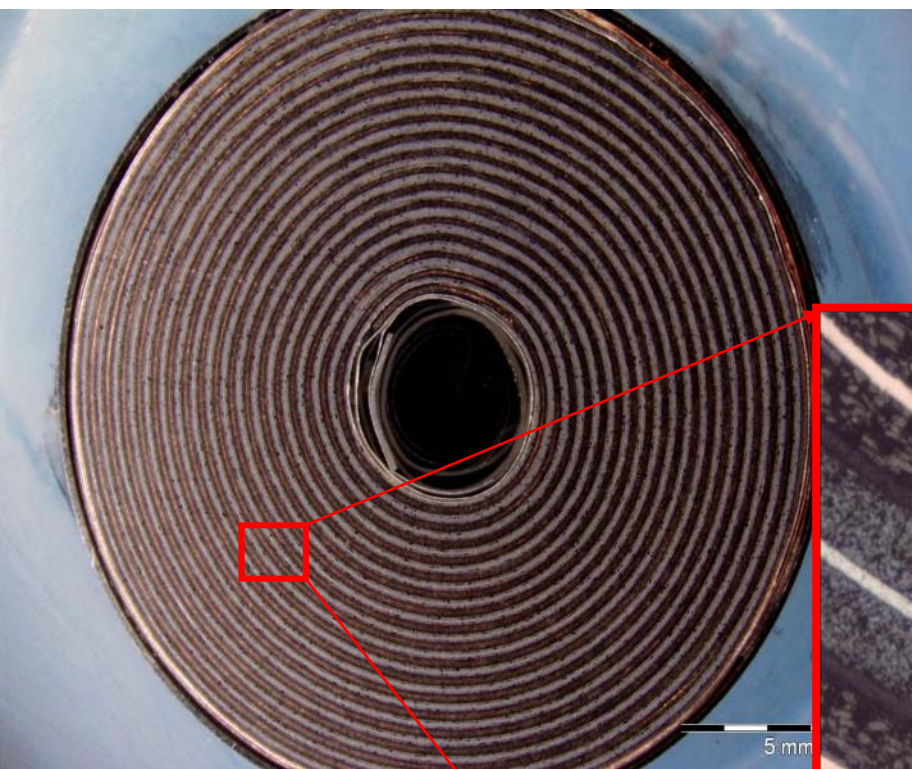


- **Power (the speed at which energy can be used):**
 - energy/time
 - Units: Watts (W)
 - Other common units include horsepower, BTU/hr

Construction

- There are three common lithium-ion cell form factors:
 - cylindrical
 - prismatic
 - pouch (aka “polymer”)
- Cylindrical is always a wound design.
- Prismatic and pouch can be wound or layered.
- Each form factor has unique manufacturing requirements and components that impact cost and reliability.







WL: 124 WW: 121

SPL



RP

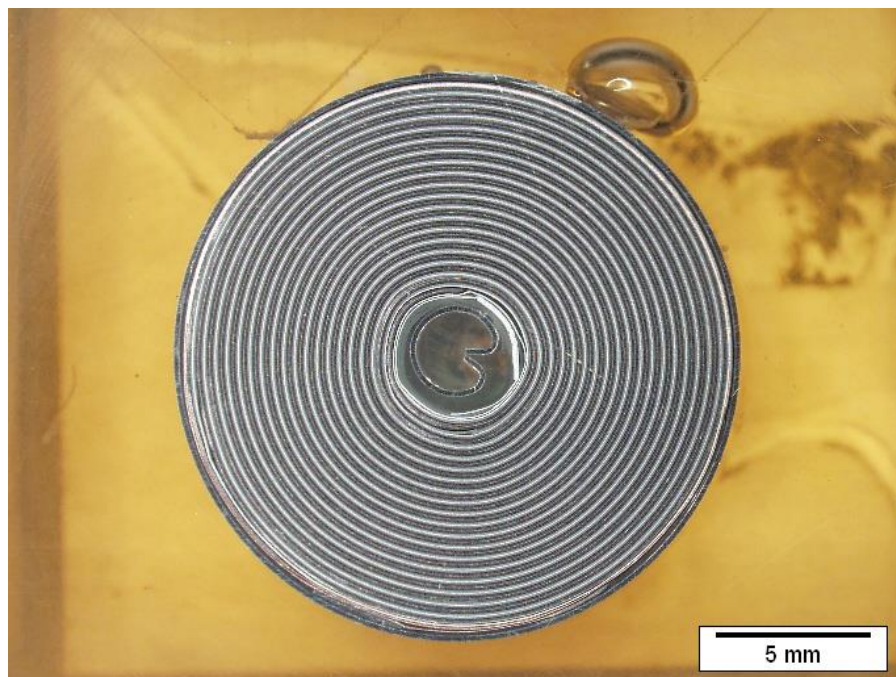
LA



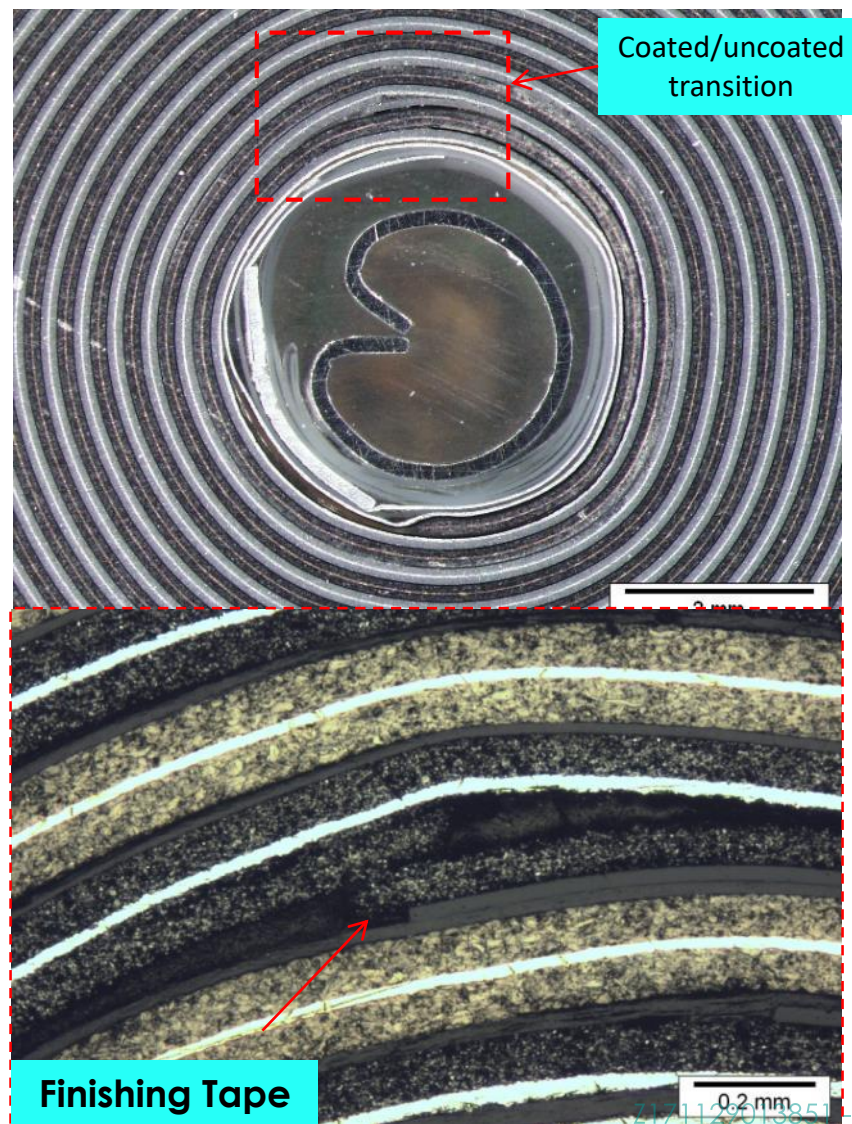
IAR



Cell Analysis – Possible Failure Location



- Feature identified in the CT scan appears to be a delamination of the positive electrode material from its current collector.
- The site of delamination is coincident with a piece of finishing tape used to protect the transition between the coated and uncoated portions of the current collector.



Coated/uncoated transition

Finishing Tape

0.2 mm

Thank You

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