Energy Ville

Unlocking Gen. 4 & 5 Battery Materials through Interphase Engineering

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EnergyVille

- EnergyVille is an energy research cooperation between the Flemish universities and research centres imec, KU Leuven, VITO, and UHasselt
- EnergyVille's mission is to support and accelerate the transition towards a sustainable energy system

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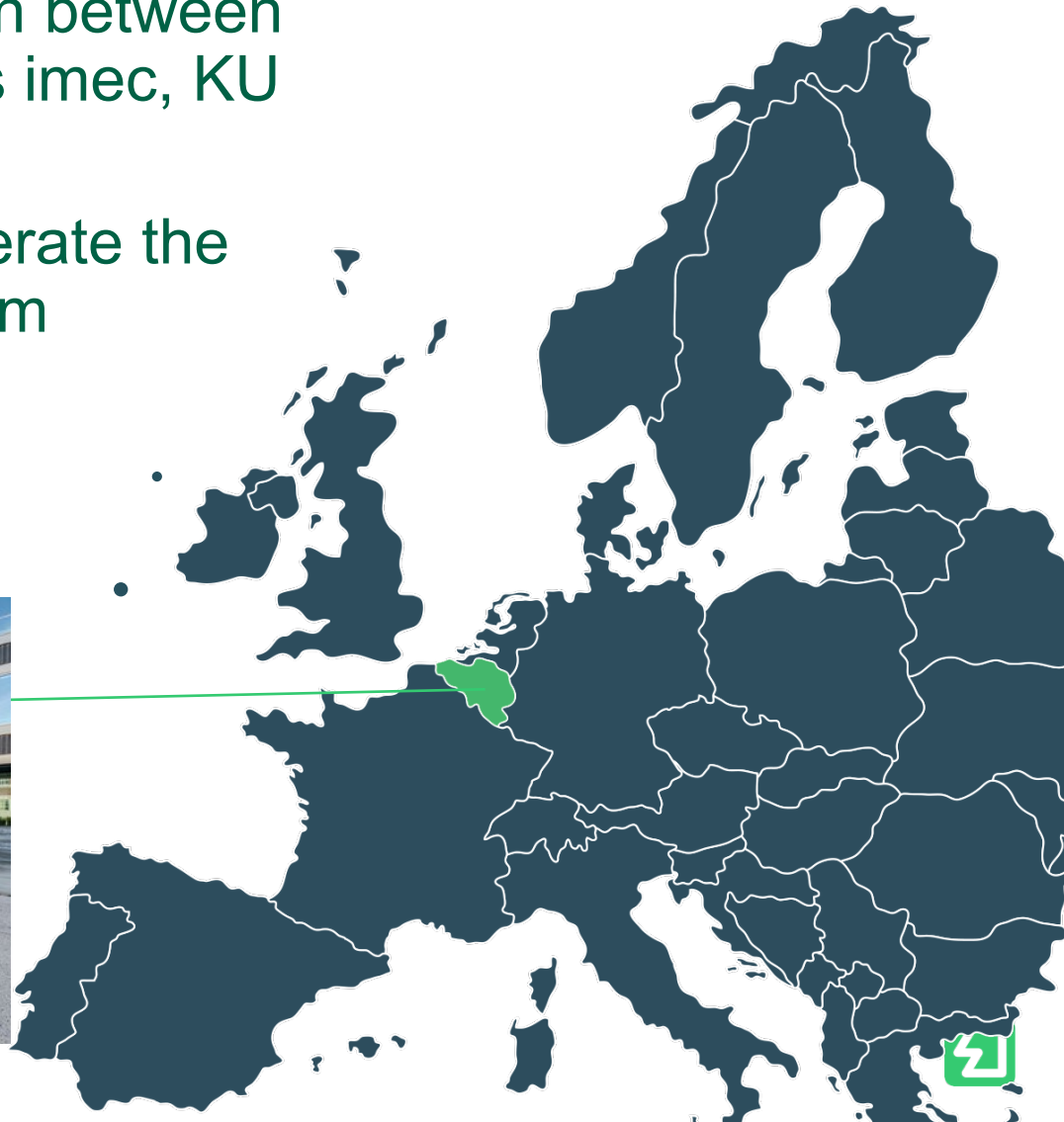
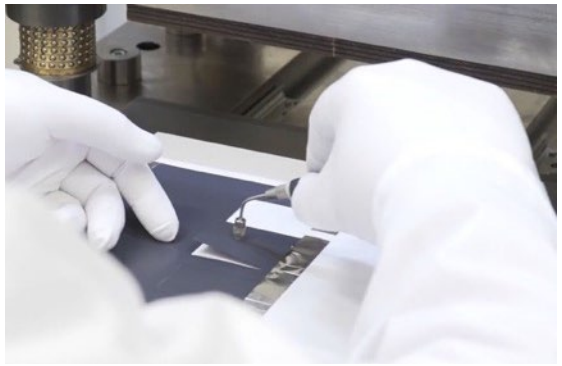


Research line battery storage

New materials for batteries

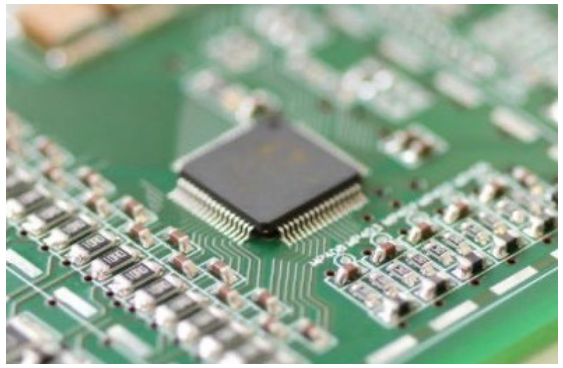
Modelling, characterisation and testing of batteries and battery materials



New battery cell architectures

Exploratory cell concepts

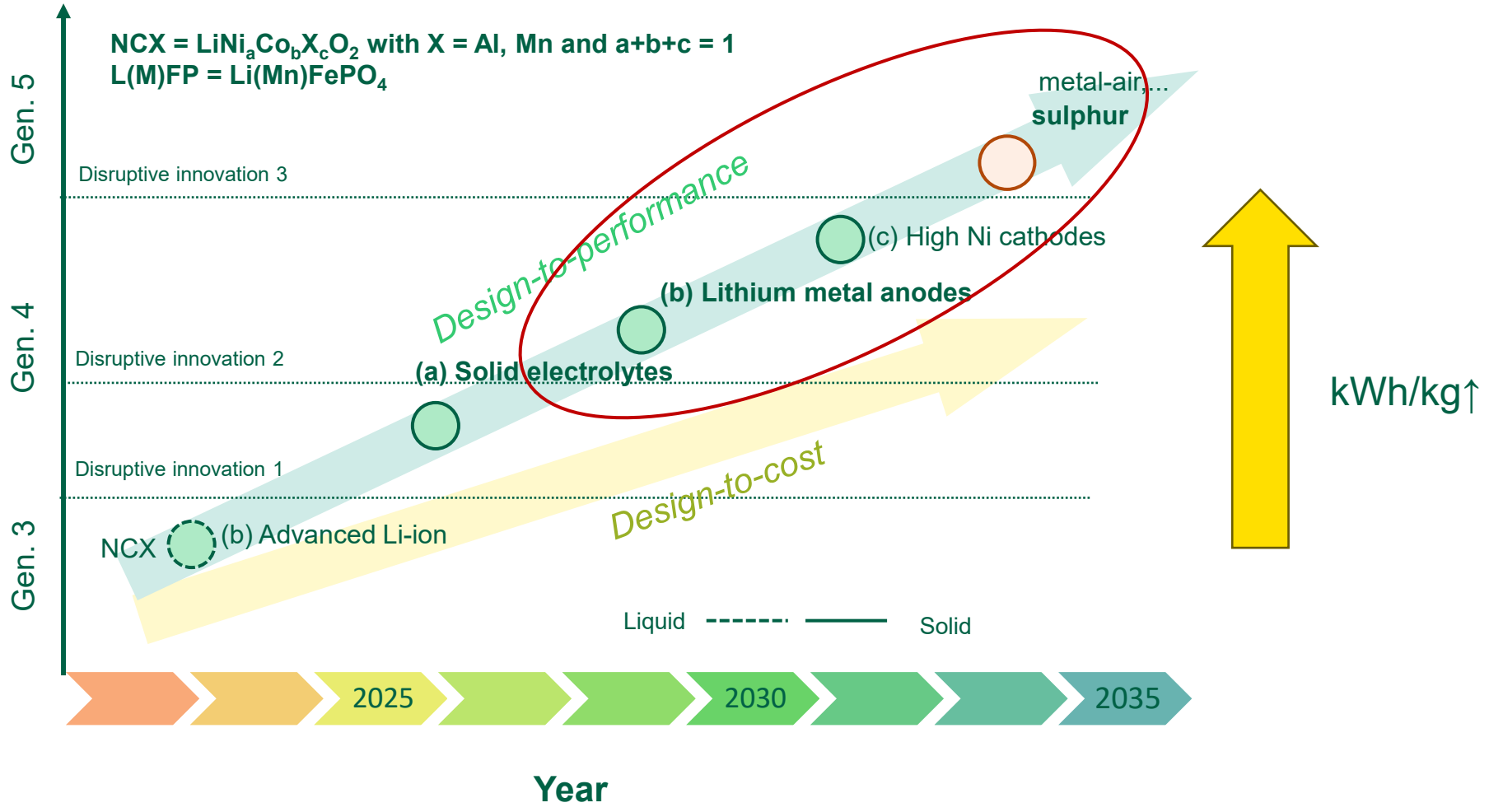
New battery concepts



Battery Management Systems

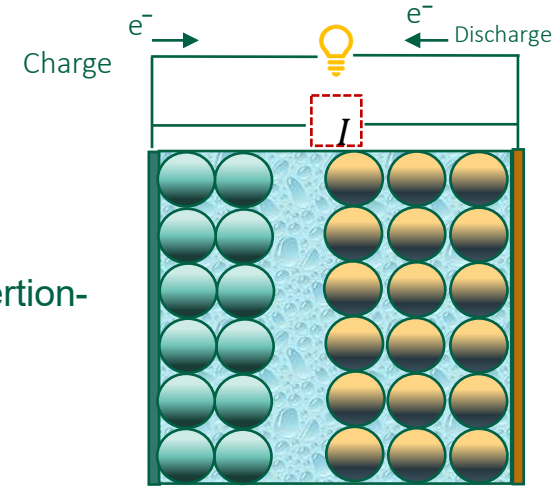
Battery integration support

Materials for next generation batteries



Lithium-sulphur

Gen. 3



Intercalation/insertion-based cathode

Intercalation-based anode

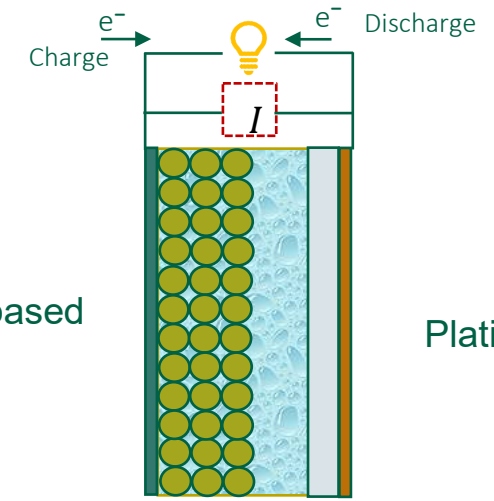
Metal oxide/phosphate cathode

Graphite anode

Li-ion batteries

- **Energy density capped** → <400 Wh/kg
- **Expensive & scarce metals** (Co, Ni)
- **Environmental burden** (CO_2 footprint, toxic mining)

Gen. 5



Conversion-based cathode

Plating/stripping

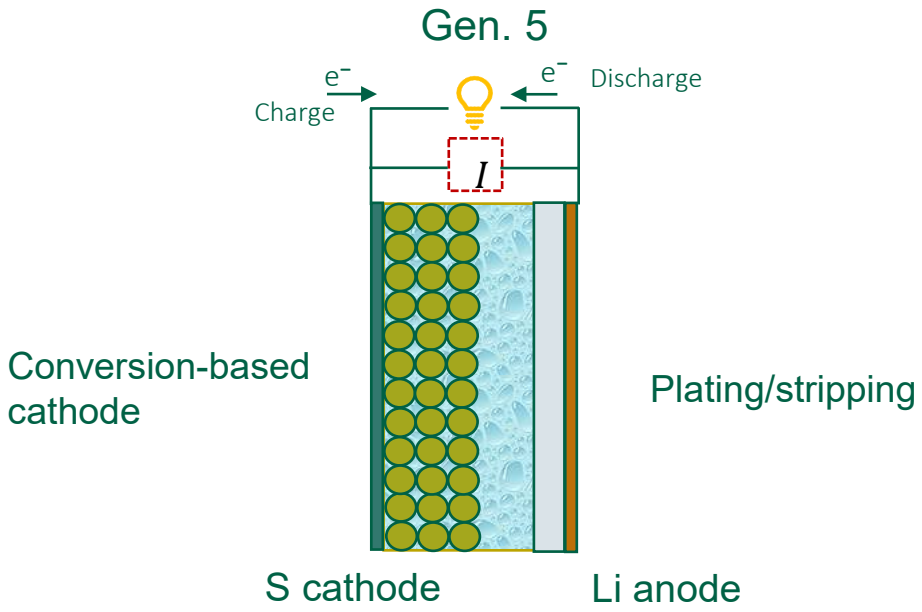
S cathode

Li anode

Lithium-sulphur

- **Very high energy density** → >500 Wh/kg
- **Sulfur is cheap & abundant** (industrial byproduct, non-toxic)
- **Lightweight electrodes** (Li & S are both low-mass elements)
- **Environmentally friendlier** (no critical metals, lower footprint)

Lithium-sulphur



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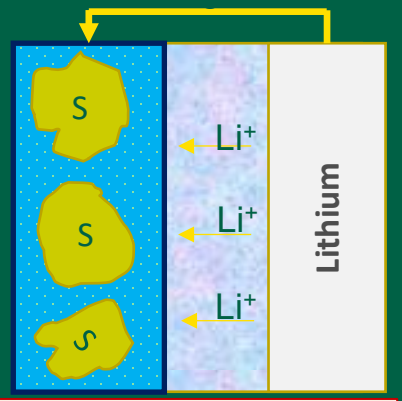
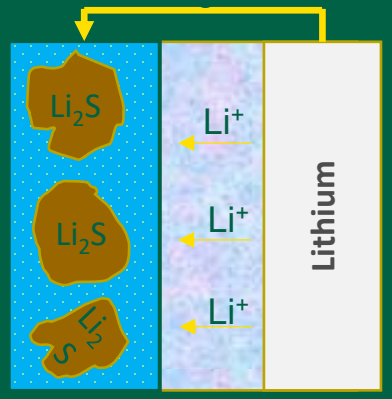
Theory vs. reality

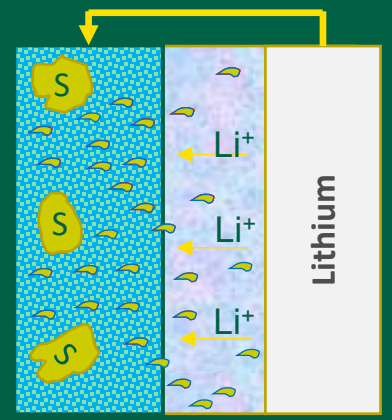


Low e^-/Li^+ conductivity of sulfur

$2Li+S \Leftrightarrow Li_2S$

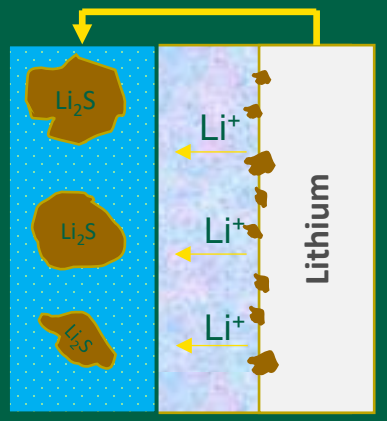


Volume change from S to Li_2S



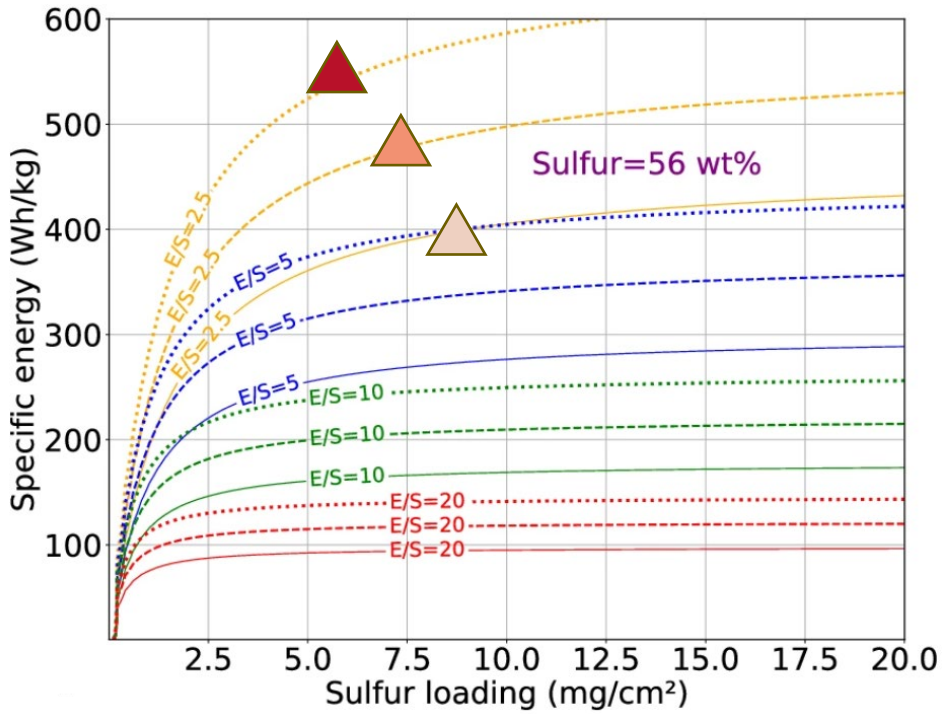
Polysulfide mobility and shuttle effect

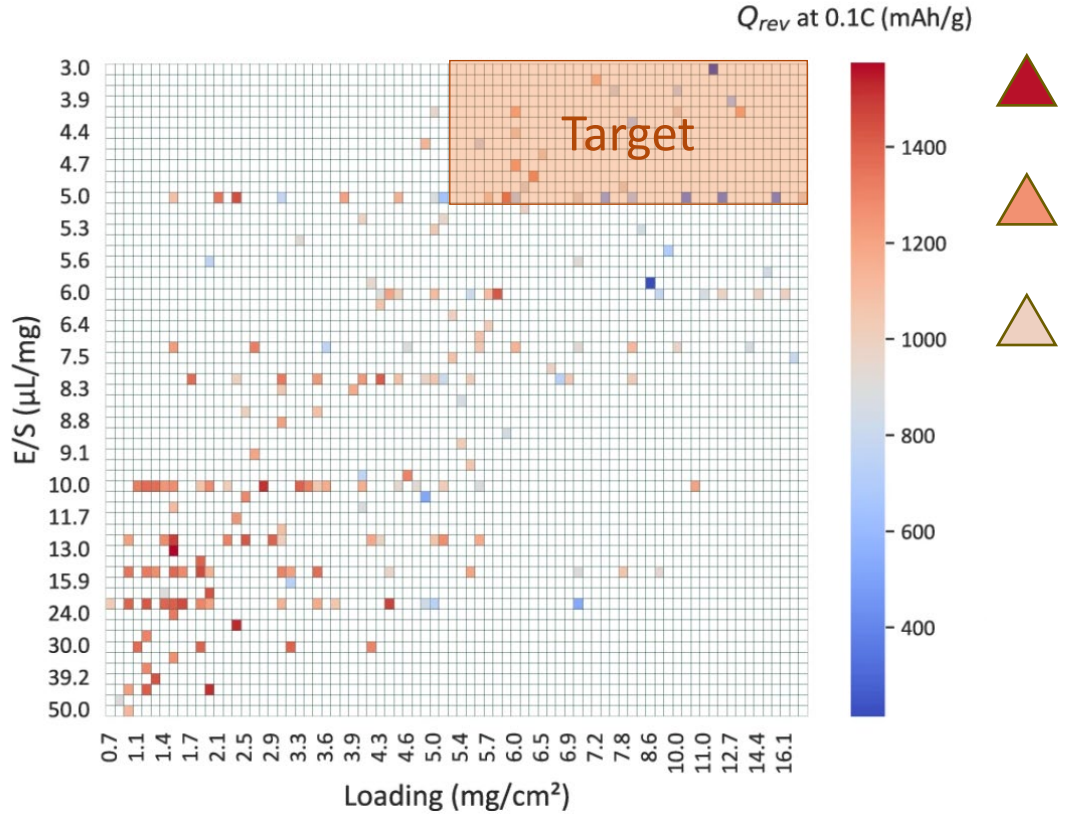
$2Li+S \Leftrightarrow Li_2S$



Formation of Li dendrites

Potential vs. Reality





Outperforming Gen. 4 = High loading + High accessible capacity + Limited electrolyte weight

Unlocking Gen. 4 & 5 Battery Materials through Interphase Engineering

1 GWh = 1-10,000,000 m^2 of electrodes

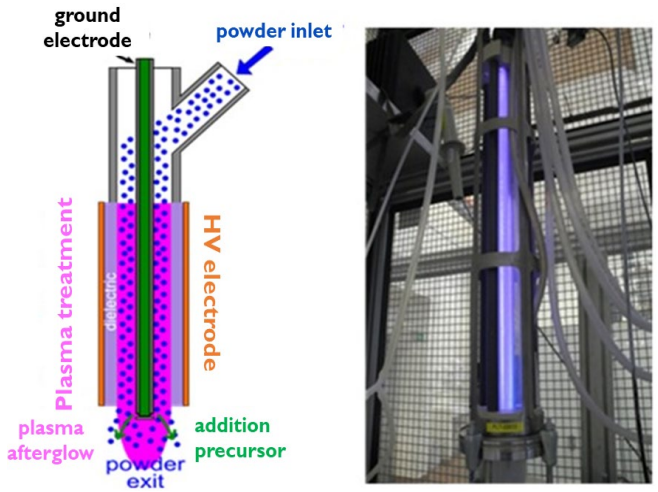
Scalability, cost and sustainability come first

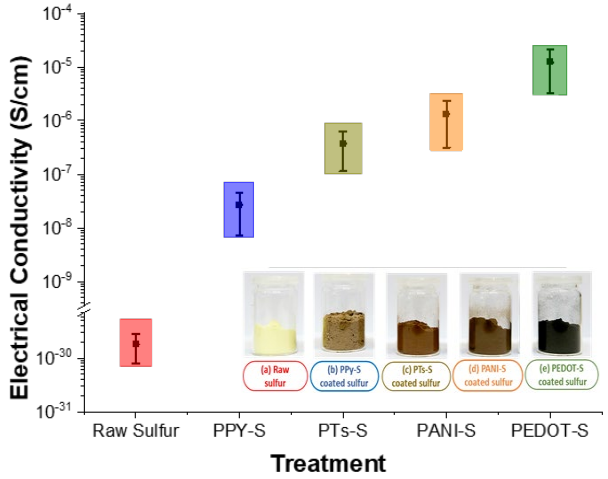
Atmospheric plasma modification of the cathode active material interface

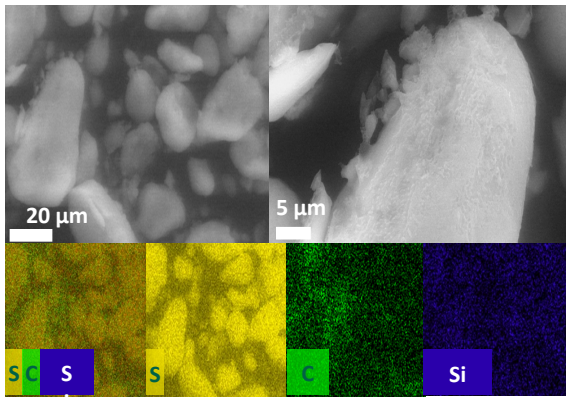
Low e^-/Li^+ conductivity of sulfur → Interphase engineered cathode active materials

Atmospheric plasma modification

- Dry, gas phase process (no drying steps, no post processing)
- Low energy (T < 80°C), ambient pressure, no solvent
- Low amount of chemical needed
- High flexibility in precursor (gas or liquid) and powder
- Up-scalable, kg/day range possible today



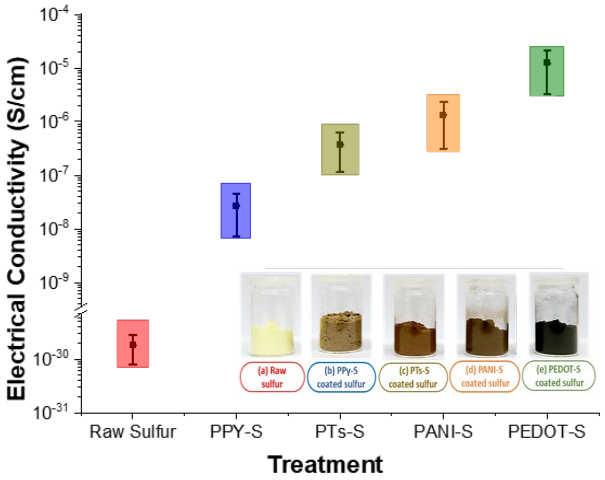


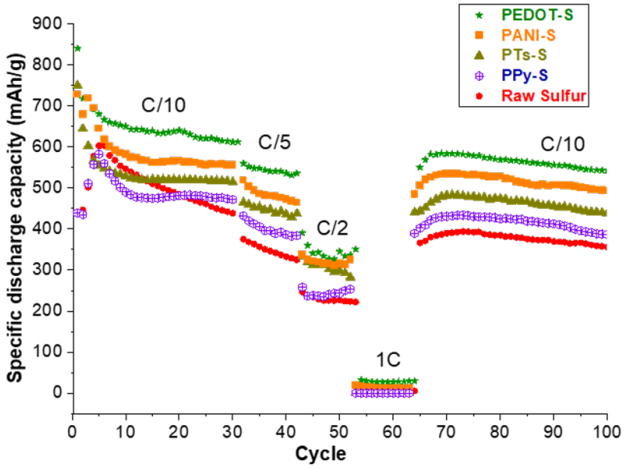


Atmospheric plasma modification of the cathode active material interface

Low e^-/Li^+ conductivity of sulfur

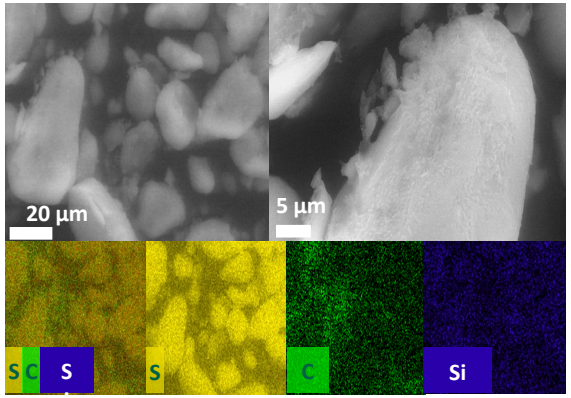
Interphase engineered cathode active materials

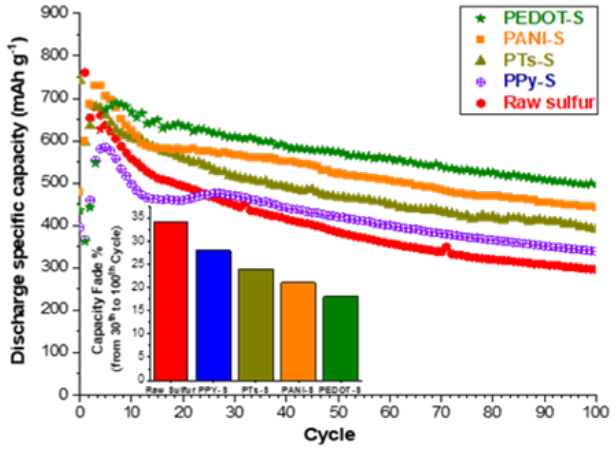




Accessible capacity ↑

Capacity retention ↑





Nano-engineering on a gargantuan scale

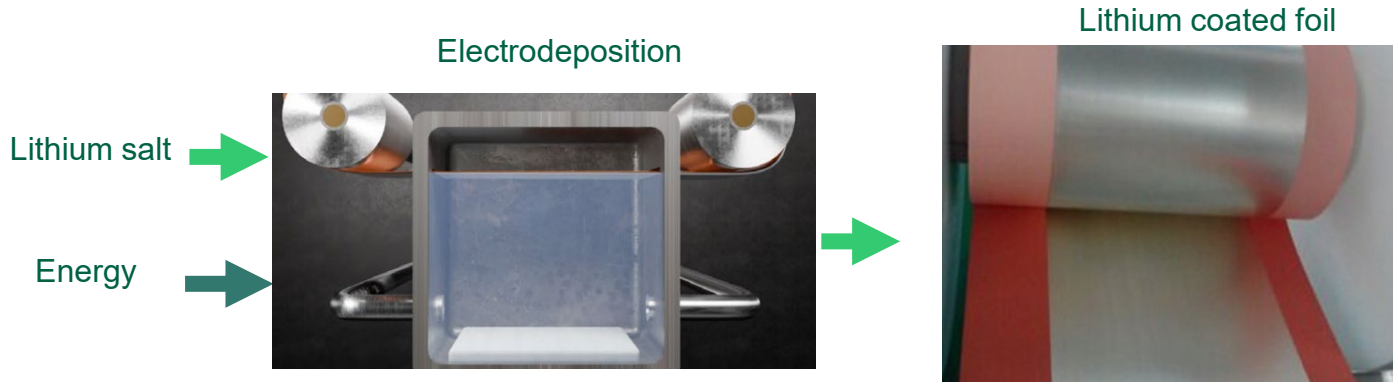
Formation of Li dendrites → Interphase engineered lithium metal anode

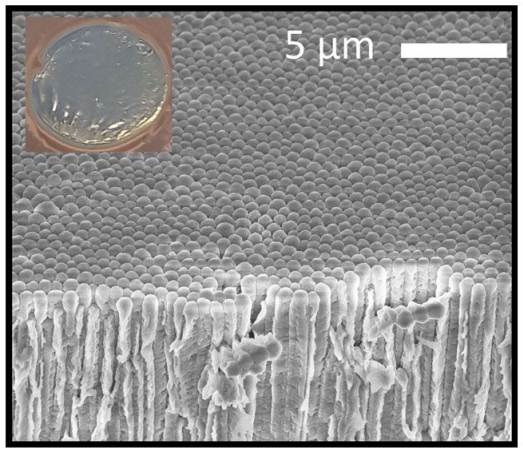
Electrochemical deposition and surface control

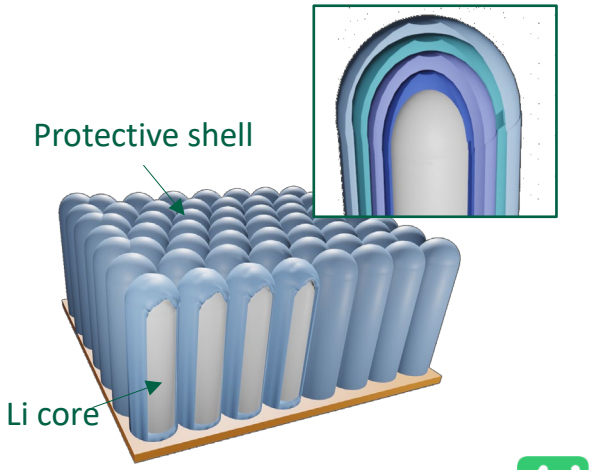
- In today's Li-ion batteries with graphite anodes, the problem of excessive reaction with the electrolyte at low anode potential is prevented by the ***solid-electrolyte-interphase or SEI***
- A healthy SEI layer over the anode is key in operation of the Li-ion cell

- **Our approach:** Stabilization in a **nano-engineered lithium anode with tunable interphase layer**

- **Compatible with production needs**







Nano-engineering on a gargantuan scale

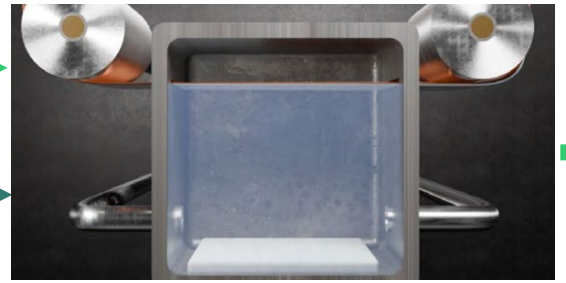
Formation of Li dendrites

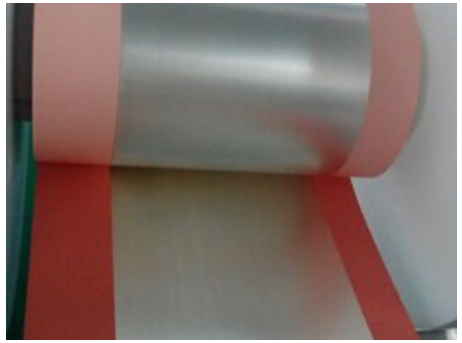
Interphase engineered lithium metal anode

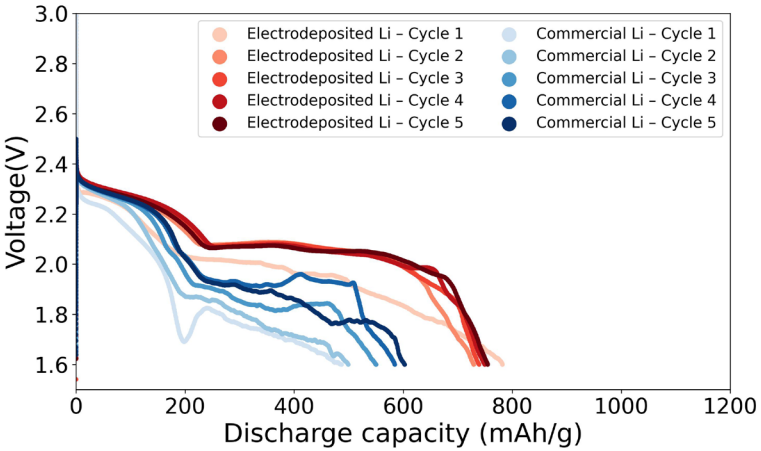
Electrodeposition

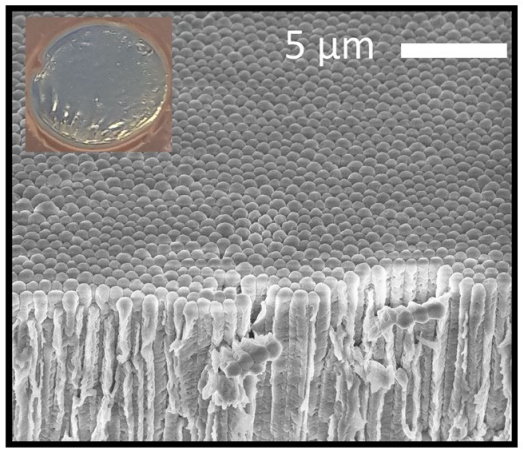
Lithium salt

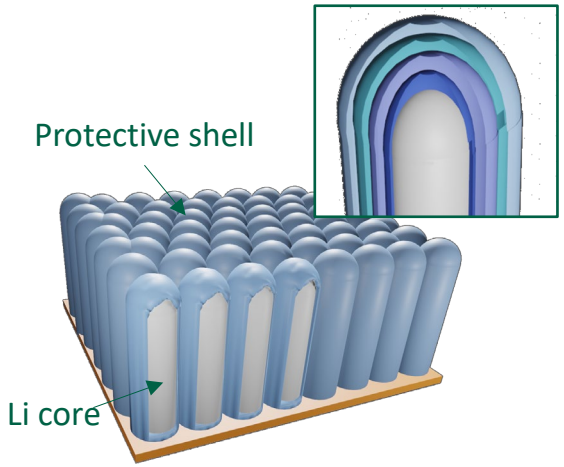
Energy

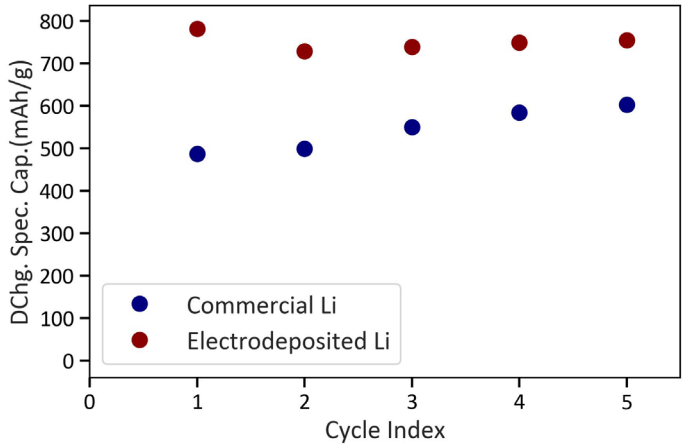












Conclusions

- Gen. 5 battery chemistry, including lithium-sulphur, requires disruptive innovation
- Interphase control of both cathode and anode significantly enhance cell operation
- Scalability and affordability first

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ENERGY IN TRANSITION