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University of Oxford

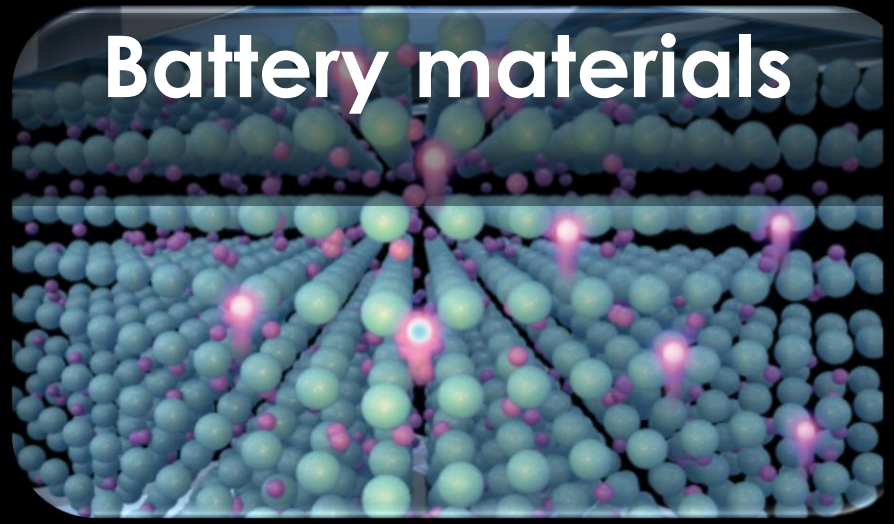
Making a Materials Difference To Batteries for Transport

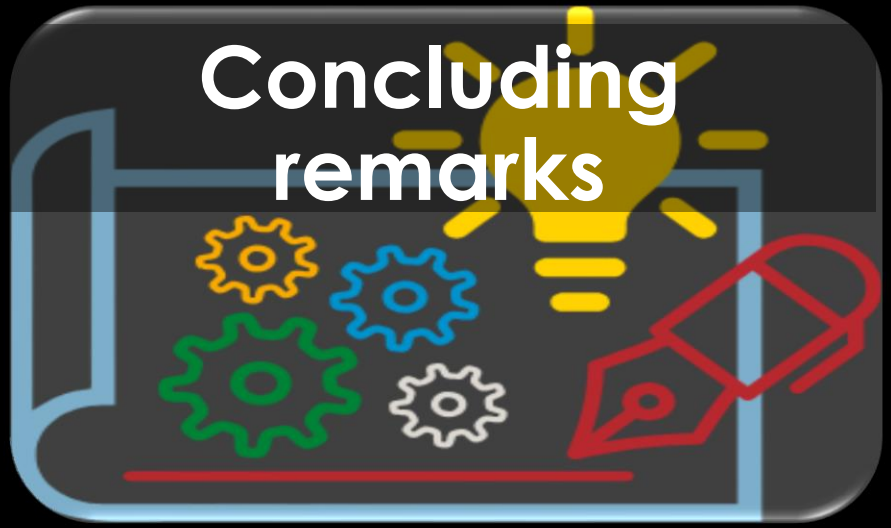
11th Oxford Energy Day, Sept 2023

Menu


Context:
Road transport


Batteries & EVs


Battery materials


Concluding
remarks

Road Transport

25% of CO_2 emissions – what can be done?

Manage Demand

- Travel Less

- Use best transport mode

- Manage transport network

Improve Technology

- Reduce vehicle mass

- Improve cars – go EV

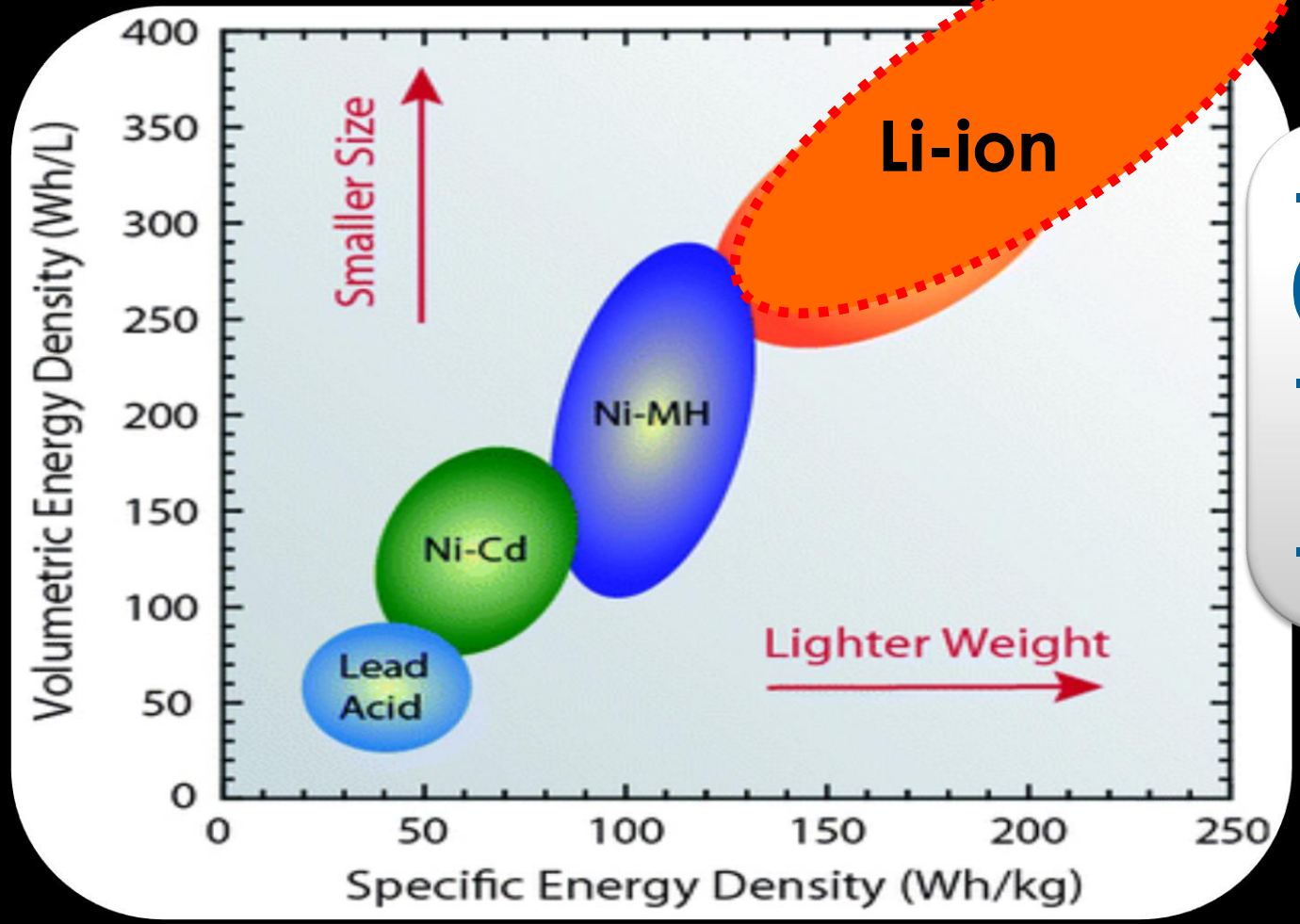
- Reduce carbon in fuel

Electricity & Whole Energy Systems

EVs reduce carbon emissions - but require charging…

EV Batteries:
Why Lithium?

Why power cars with lithium batteries?



- Efficient (energy in/out 90%)
- Electricity infrastructure
- They work!

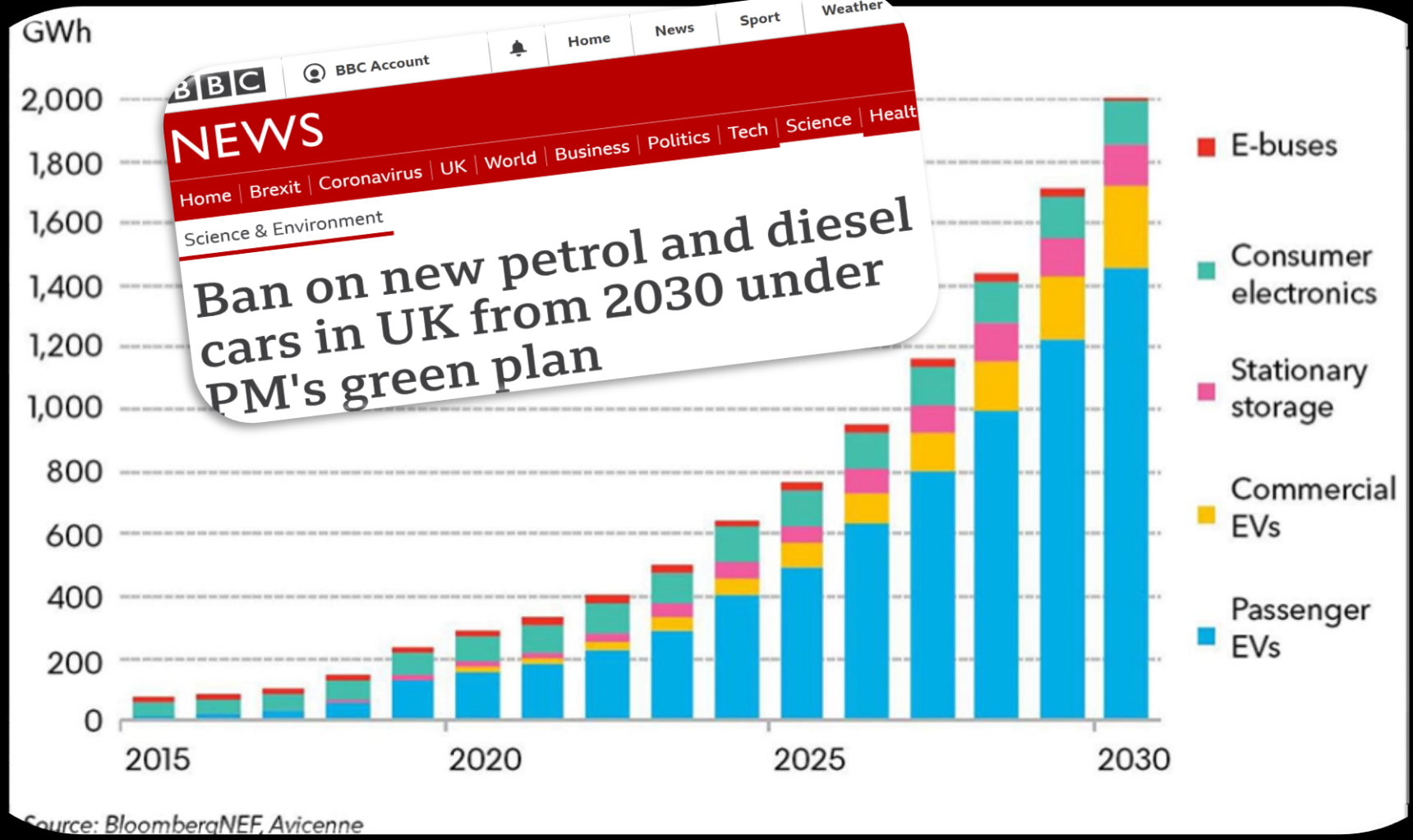
Batteries: Advances & Innovation?

Innovation: new materials, new sustainable concepts & underpinning science

Devices: manufacture & performance

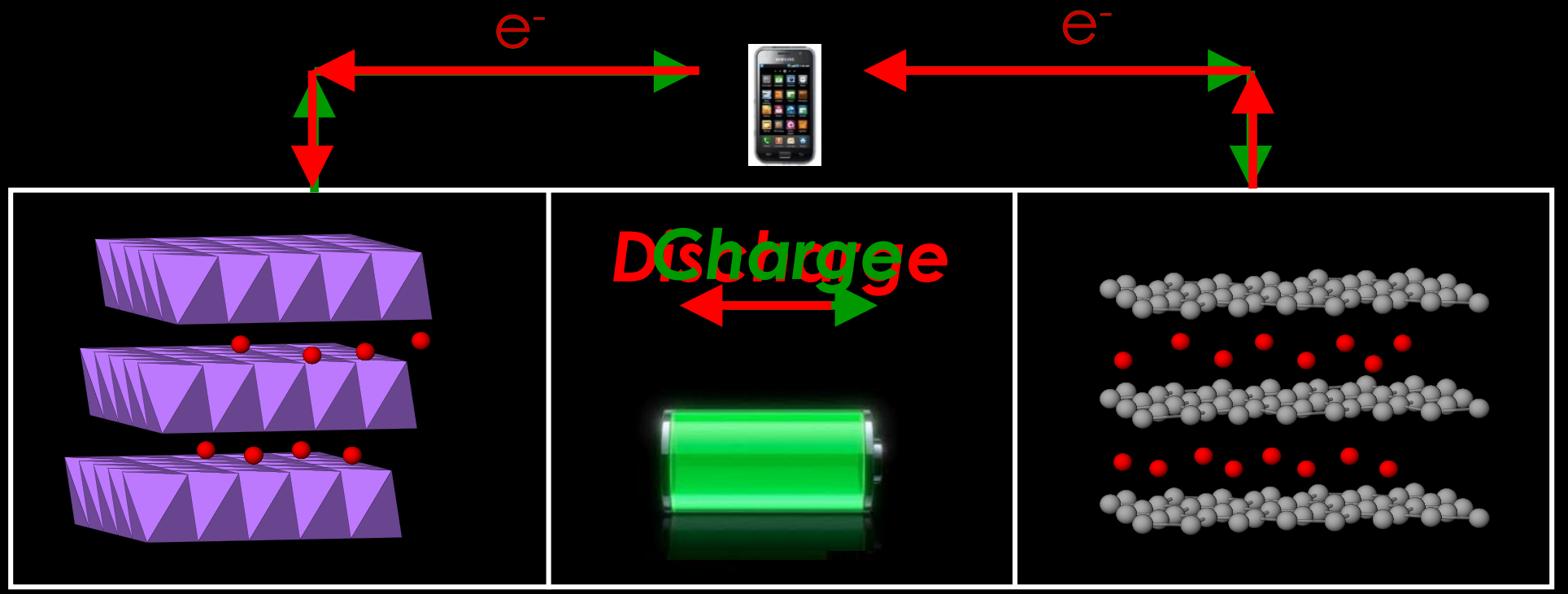
Li-ion battery market

- Battery market growth predicted - due to transition to EV



Lithium-ion batteries:
What's inside them?

Inside lithium-ion battery?



$LiCoO_2$ cathode

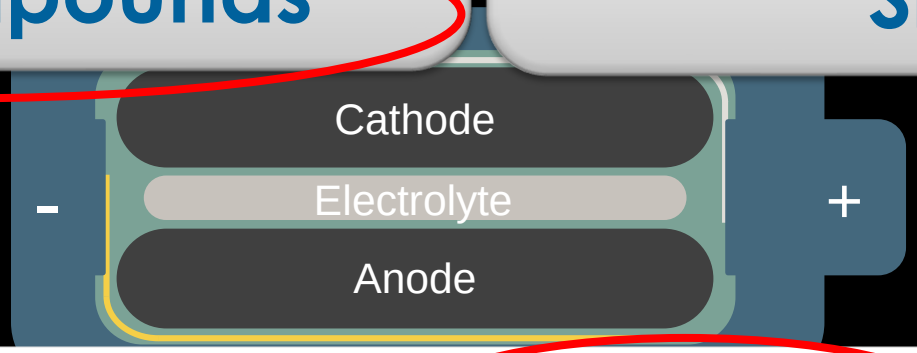
Electrolyte

Graphite anode

Areas of battery materials science

Cathode
Ni-rich $Li(Ni,Mn,Co)_2$
Li-rich compounds

Anode
Lithium metal
Silicon



Electrolyte: solid-state

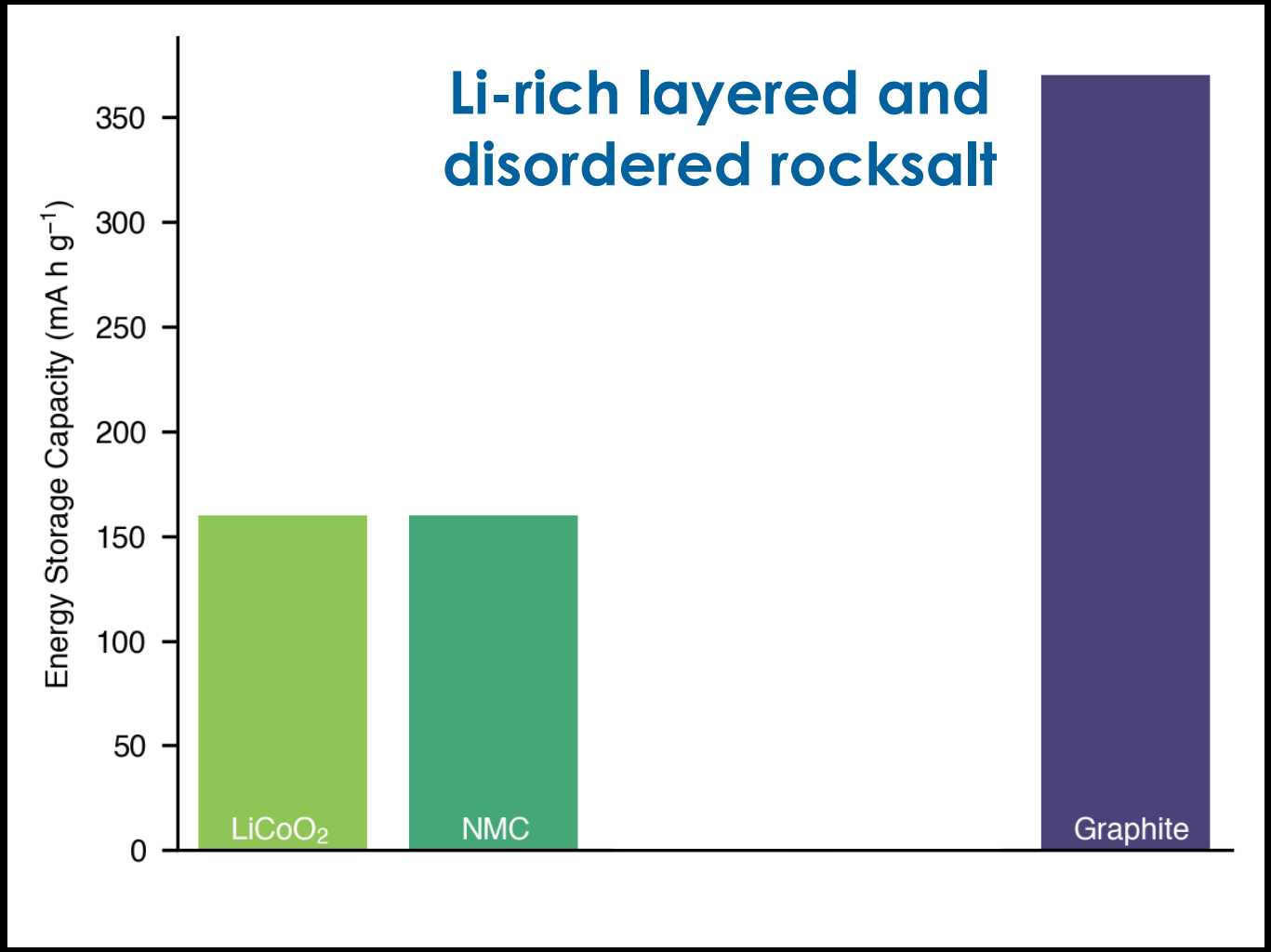
Beyond Li-ion: Na+, Mg2+

Beyond Intercalation: Li-S, Li-O_2

Cathodes:
Why do we need new materials?

Higher energy density materials?

Store charge on metal AND oxygen → O-redox cathodes



The Faraday Institution

THE FARADAY INSTITUTION CATMAT

NEXT GENERATION LI-ION CATHODE MATERIALS

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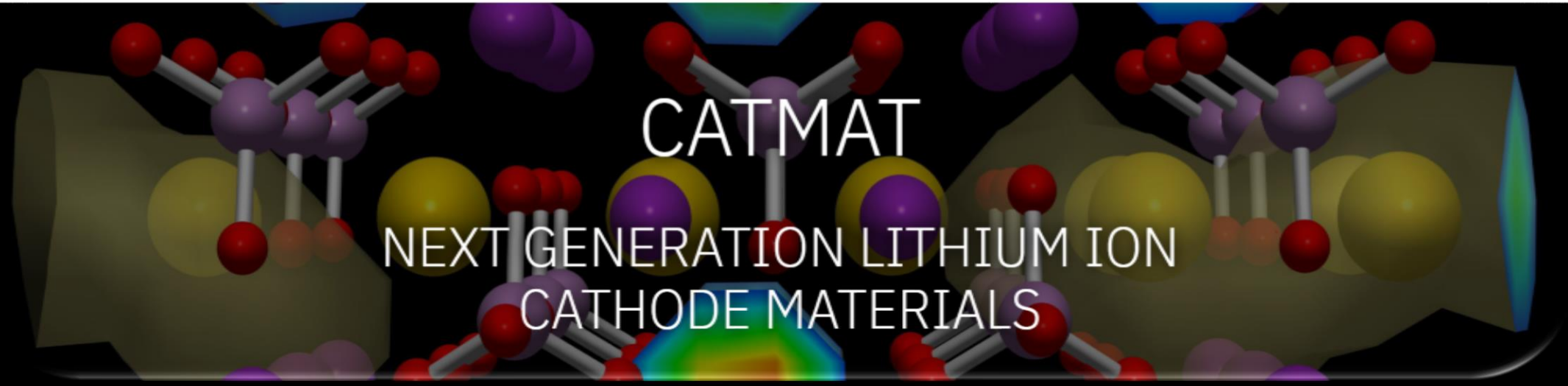
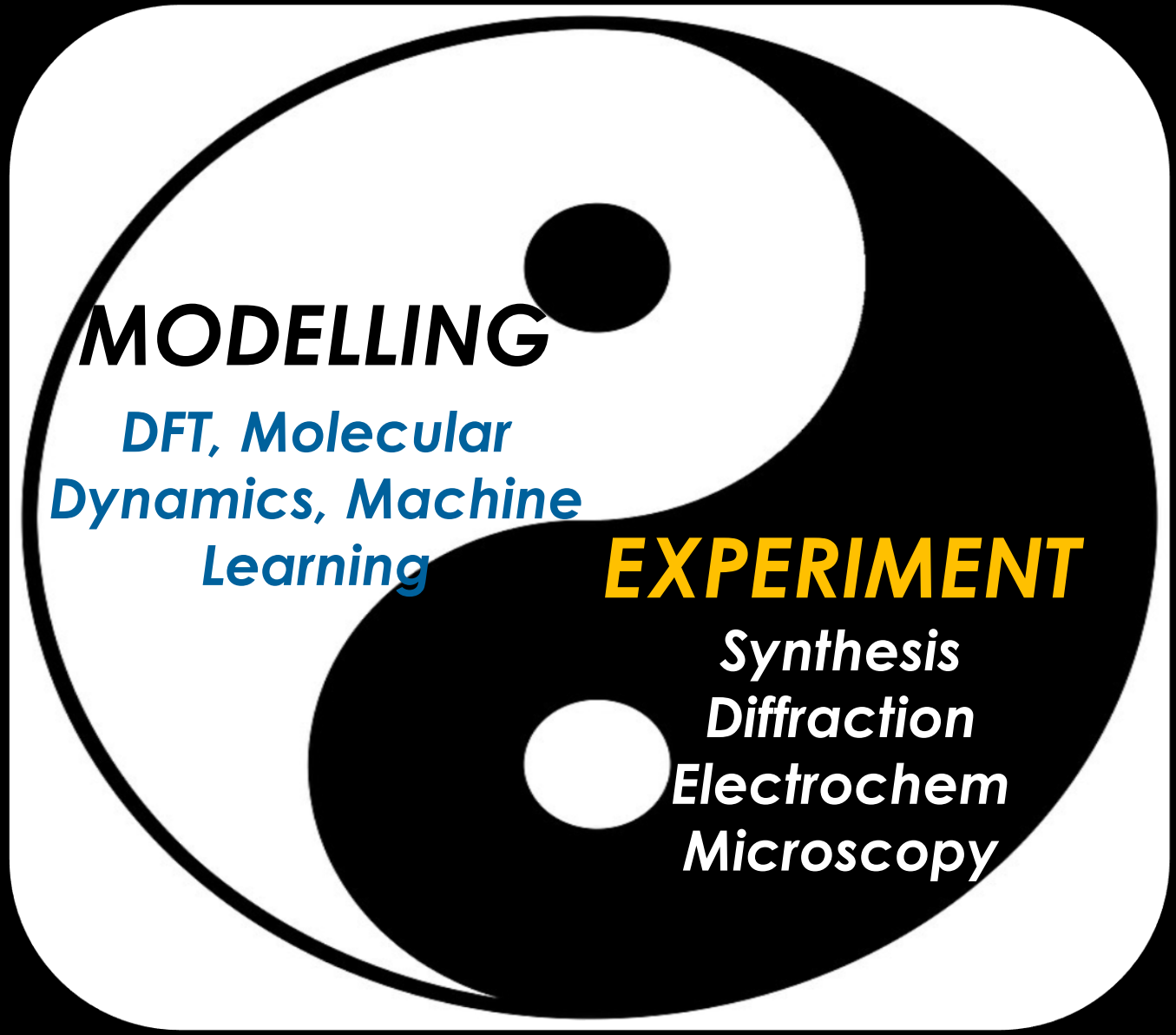
Catmatproject.com



Lead (PI) SI (Oxford) + Bruce, House, Shearing

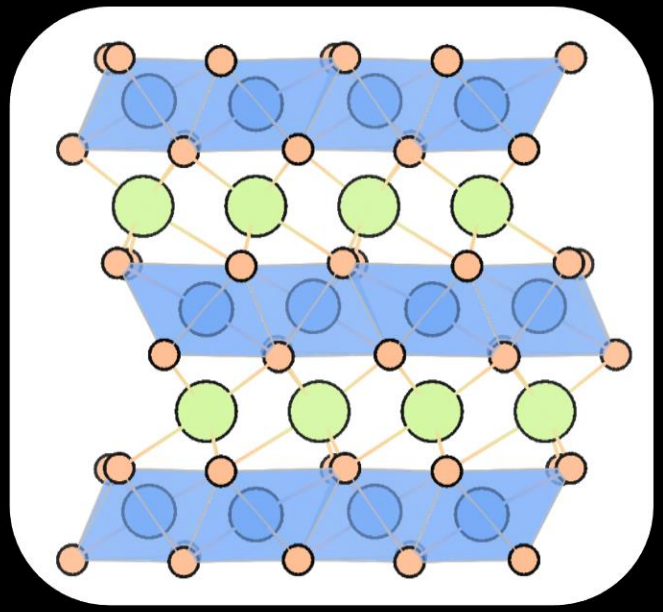
Partners: Grey (Cambridge); Slater/Kendrick (Birmingham), Rosseinsky (Liverpool)

Modelling-experimental synergy

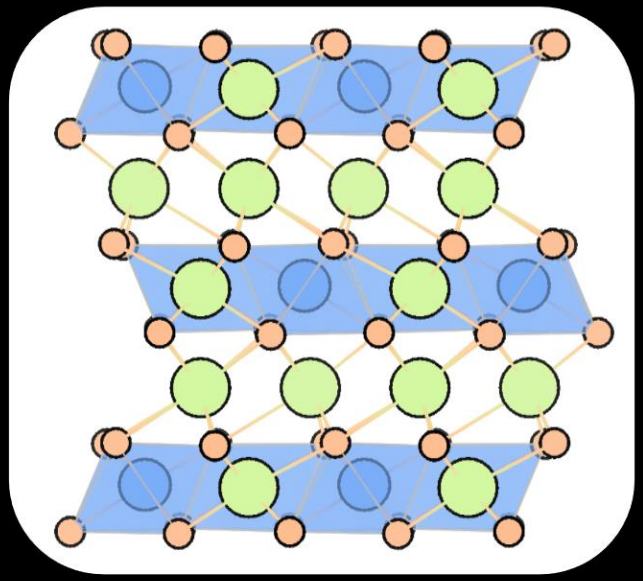


Li-Rich Cathode Materials:
What are they?

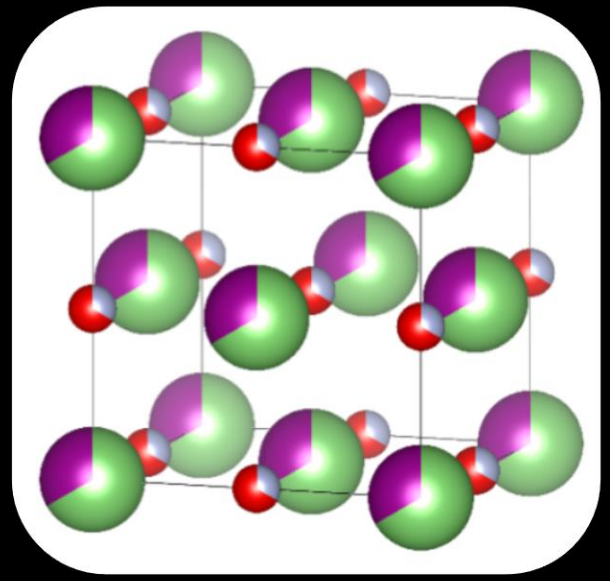
Li-rich cathode materials: Li/M > 1



$LiMO_2$

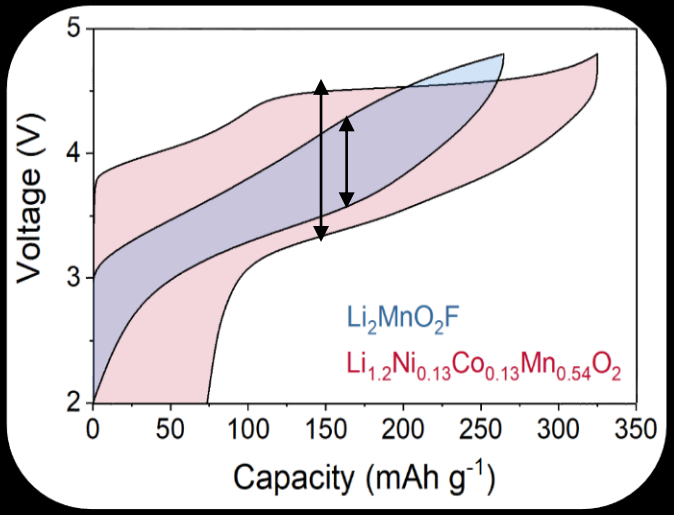


$Li_{1+x}M_{1-x}O_2$



Li_2MnO_2F

- Current ~ 200 mAh/g
- Li-rich > 280mAh/g
- No Co - but voltage loss



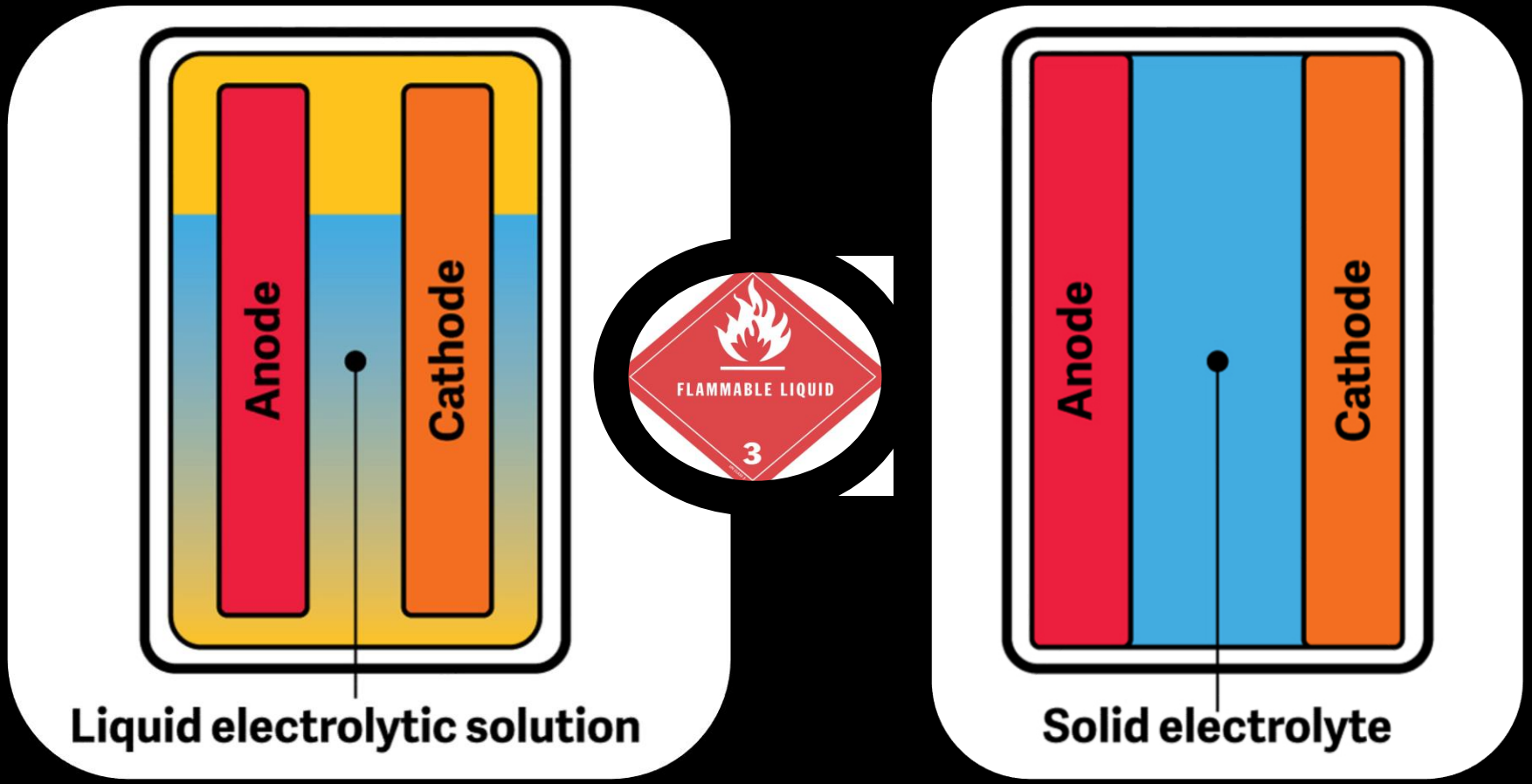
First cycle load curves

Challenge: recycling of batteries

- ❑ Reducing cobalt
- ❑ Earth-abundant elements
- ❑ End-of-life recycling – legislation?

Future Outlook:
What is Beyond Lithium-Ion?

All Solid State



Safety, stability, high energy density (Li anode)

Solid Electrolytes

- *Issues*: conductivity, transport mechanisms, interfaces?

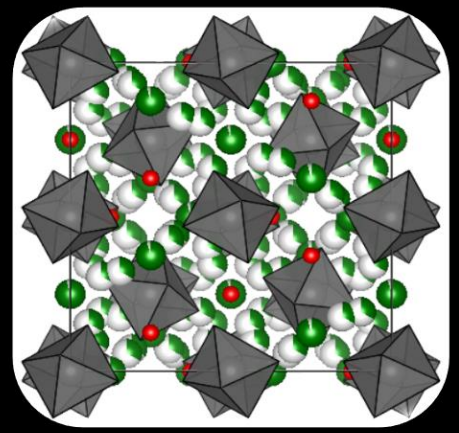
nature materials

REVIEW ARTICLE

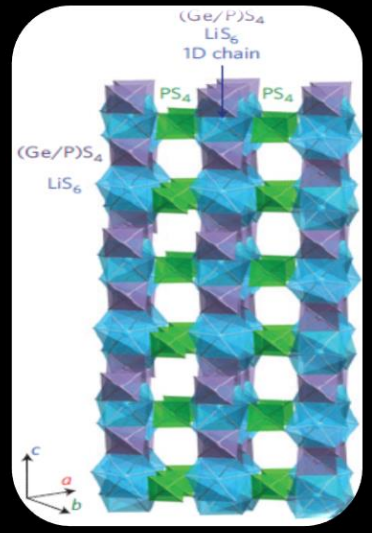
https://doi.org/10.1038/s41563-019-0431-3

Fundamentals of inorganic solid-state electrolytes for batteries

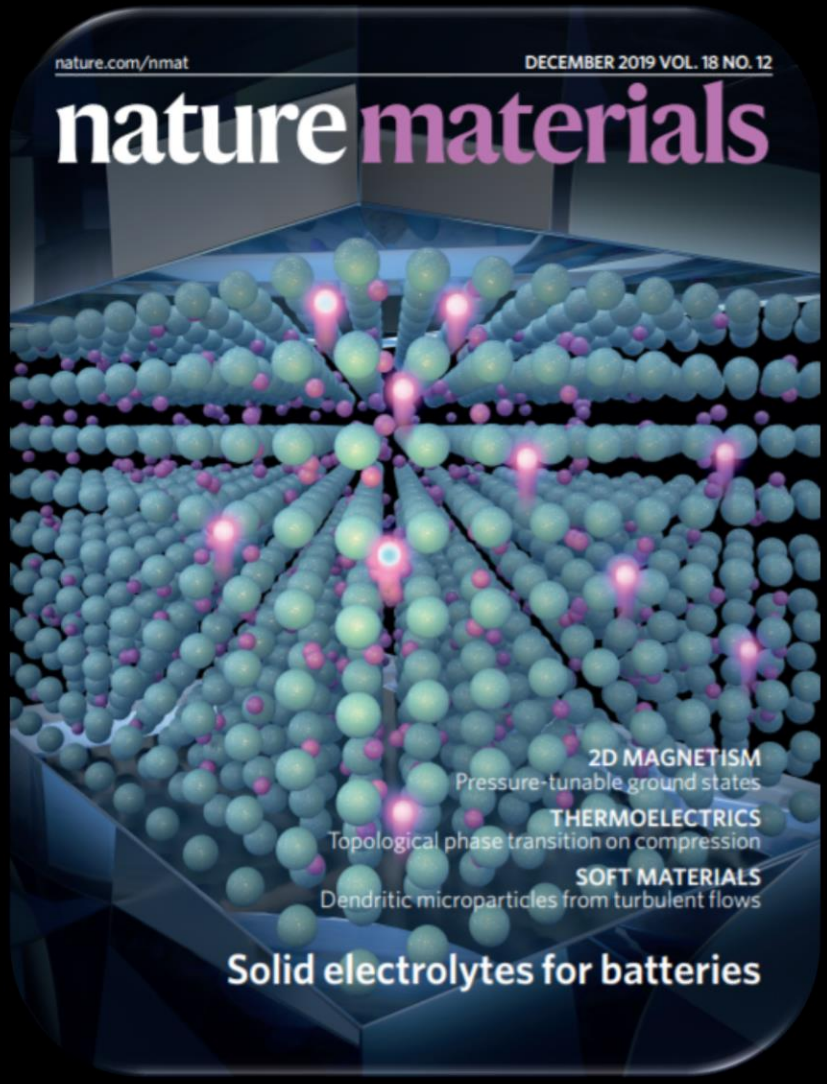
Theodosios Famprikis[1,2,3*], Pieremanuele Canepa[2,3,5], James A. Dawson[2,3], M. Saiful Islam[2,3*] and Christian Masquelier[1,3,4*]



Garnet oxides



Sulphides



Sodium-Ion Batteries

- Lithium resources
- Sodium: abundant & low cost
- Storage for grid
- New materials chemistry

Final slide:
Battery projects @Oxford

Oxford Projects & Thanks

Projects led by Oxford

Cathode materials - CATMAT (S. Islam)

Solid state batteries - SOLBAT (M. Pasta, P. Bruce)

Electrode manufacturing - NEXTRODE (P. Grant)

Lithium-sulfur – LI-STAR (P. Shearing)

The **End**