



**Empa**

Materials Science and Technology

# Innovating the batteries of the future

**Prof. Dr. Corsin Battaglia**

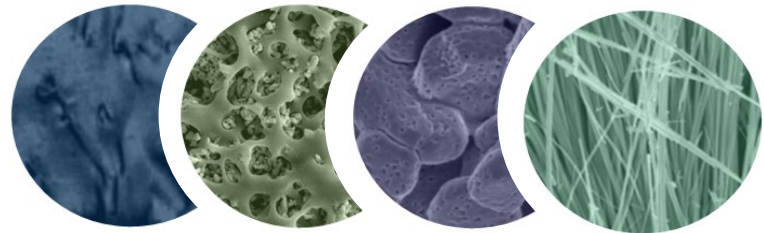
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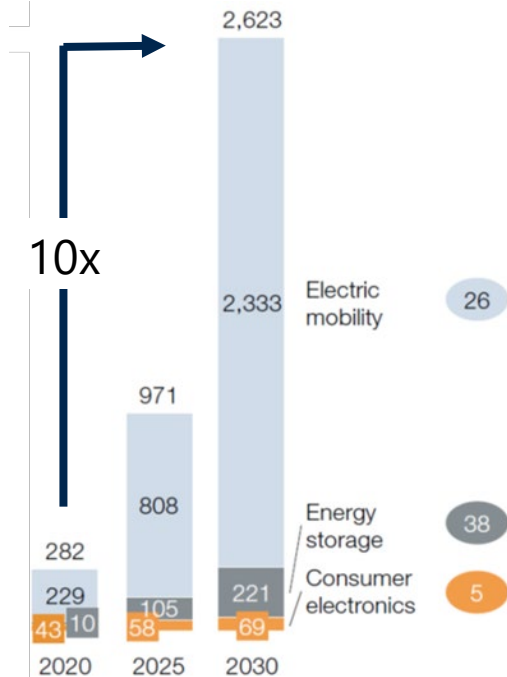
Wirtschaftscluster Energie Region Winterthur

June 29 2023

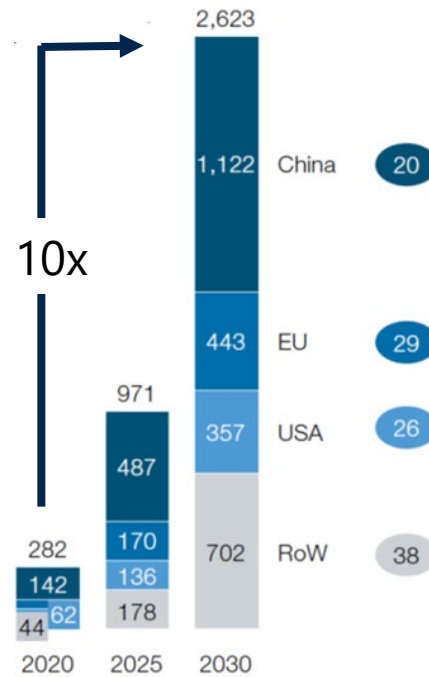


# Global battery demand

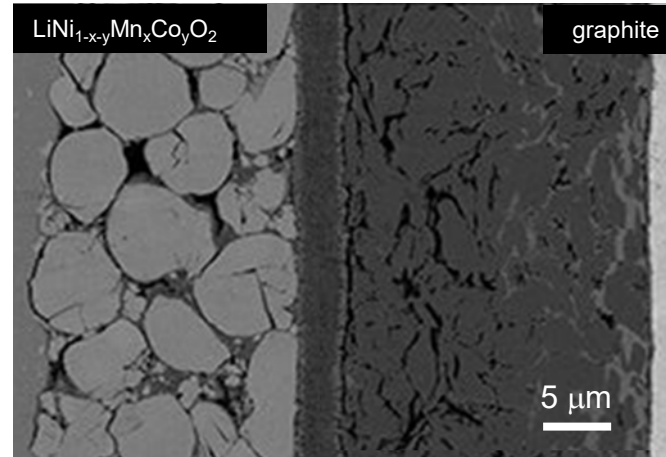
Global battery demand by application  
GWh in 2030, base case



Global battery demand by region  
GWh in 2030, base case



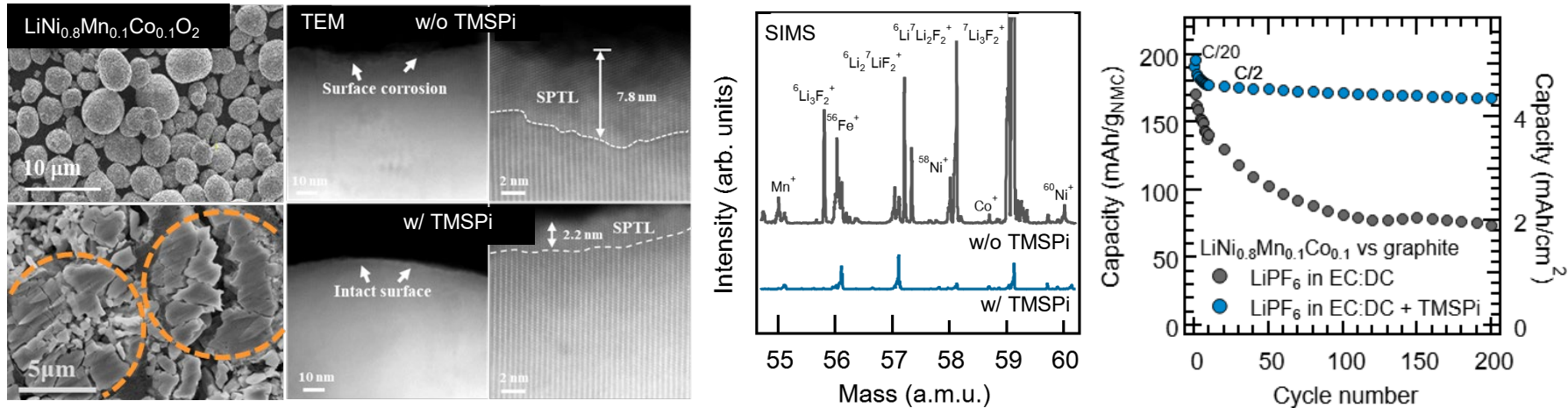
# Next-generation lithium-ion batteries



- 750 Wh/l with 3000 deep cycles at  $<100\ \text{€}/\text{kWh}$  at pack level by 2025
- Sustainability as primary differentiator for batteries produced in Europe

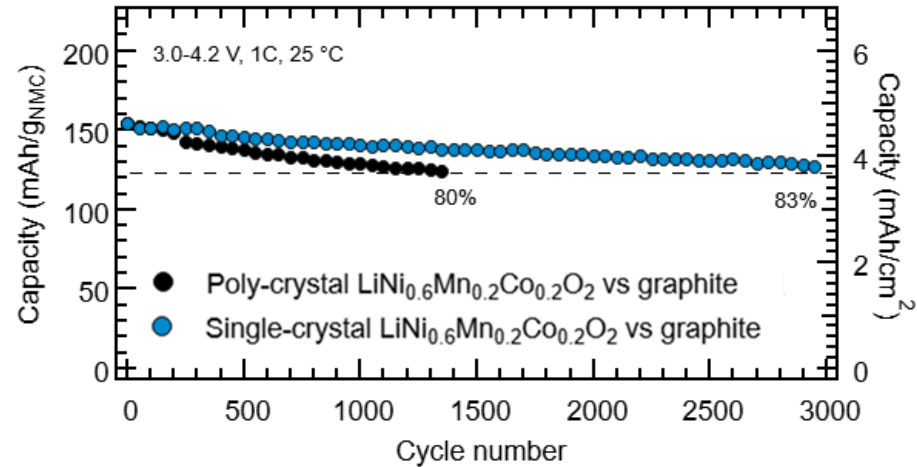
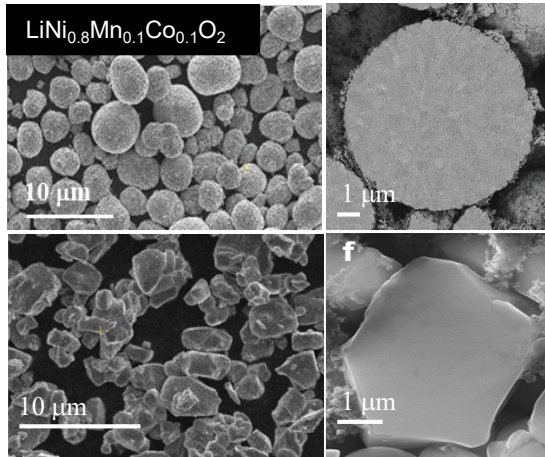


# Next-generation lithium-ion batteries



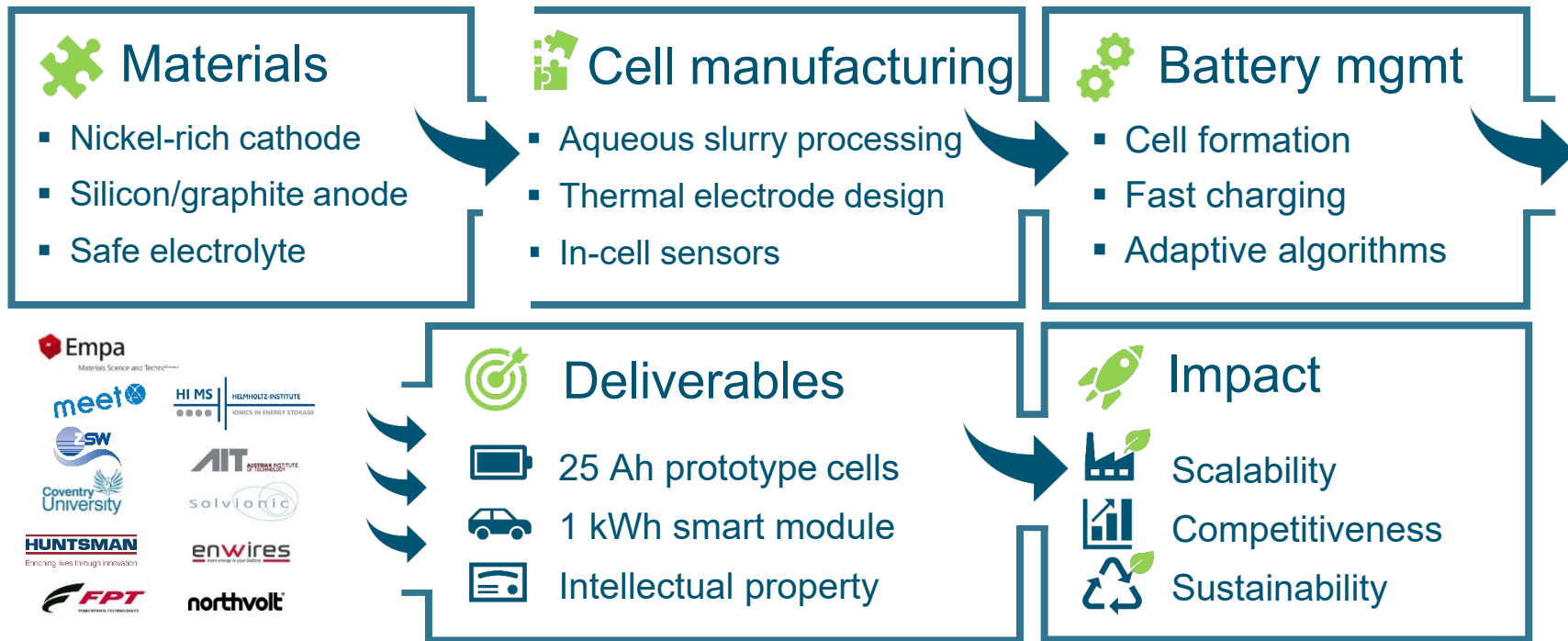
- Reduce/replace cobalt classified as critical raw materials in Europe
- Development of passivating electrolytes to stabilize reactive interfaces

# Next-generation lithium-ion batteries



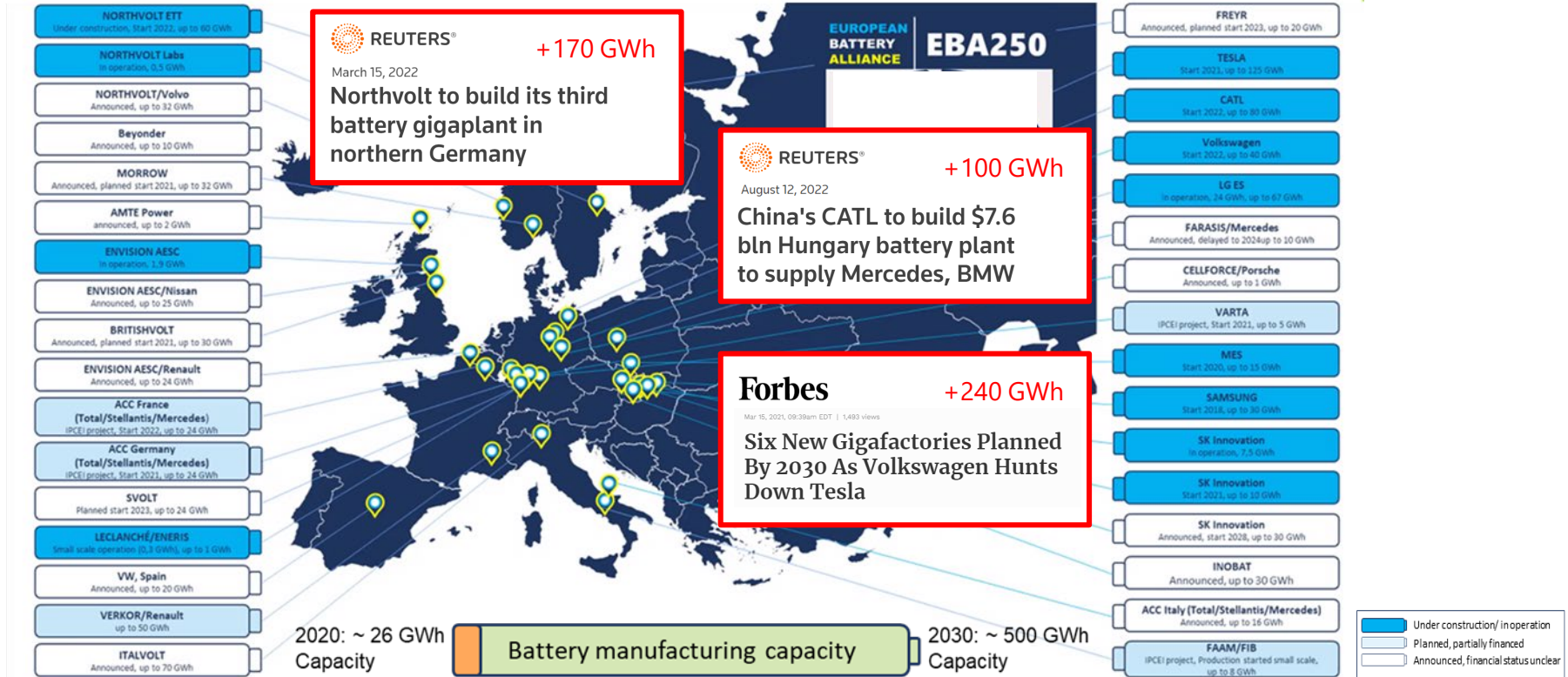
- Excellent cycling stability with single-crystal cathode materials
- ~1 million miles battery

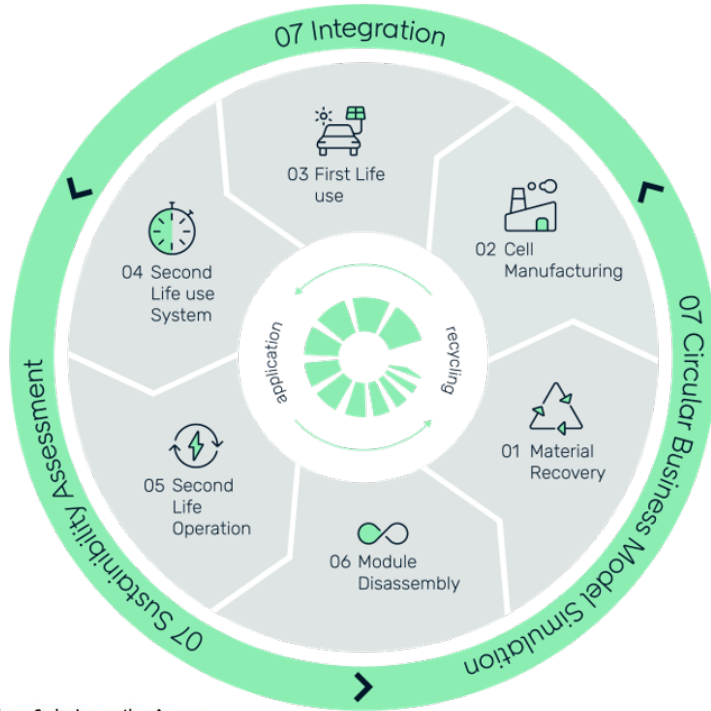
# innovation chain at a glance



€10.3 m EUR 📅 02/20 - 01/24

# Battery gigafactories in Europe



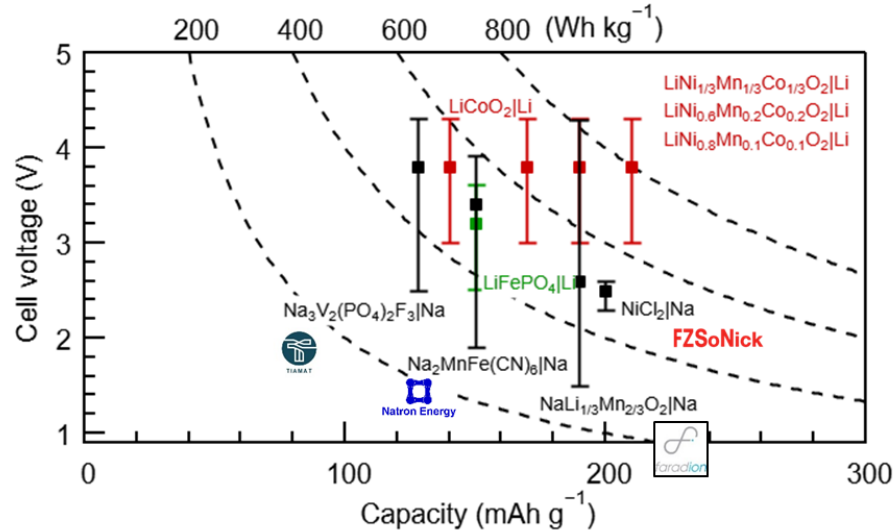


€ 7.5 m CHF 01/22 - 12/25

Establish a Swiss circular economy model for automotive lithium-ion batteries to reduce their ecological footprint.

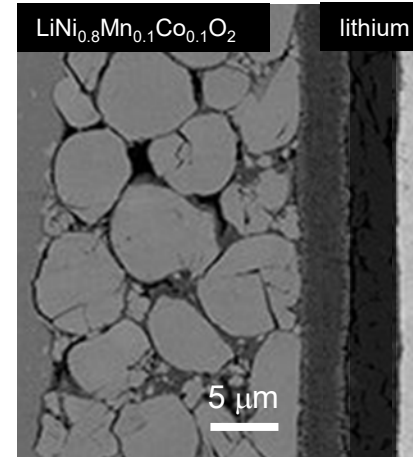
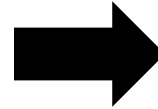
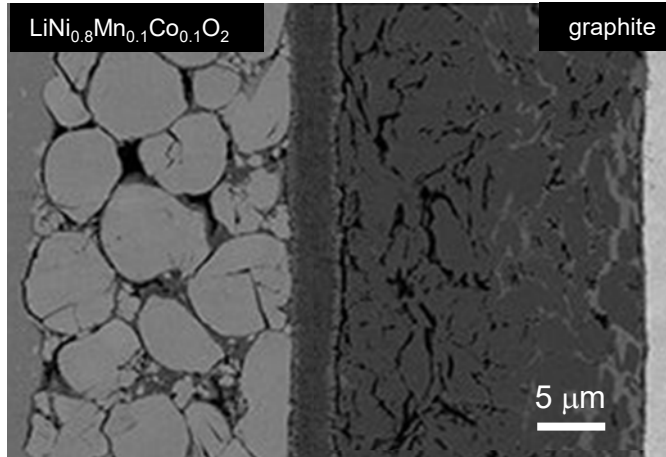


# Lithium-ion vs sodium-ion batteries



- How to eliminate lithium, cobalt, and nickel?
- Sodium-ion batteries are a viable option for electric vehicles

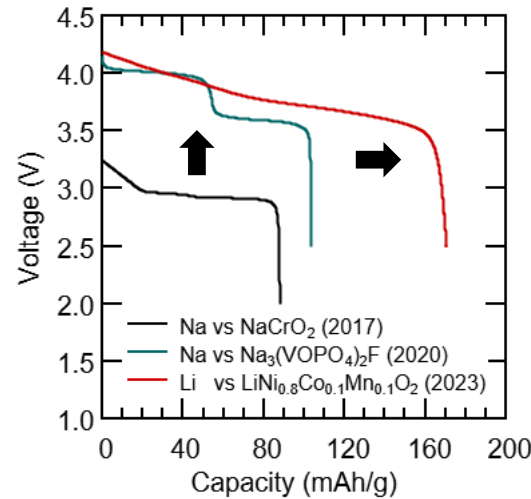
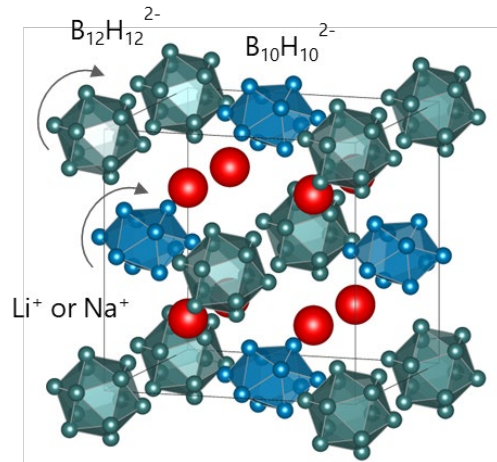
# The next big thing?



- 750 Wh/l with 3000 deep cycles
- Sustainability

- 1000 Wh/l with 3000 deep cycles
- Fast charging within <20 min

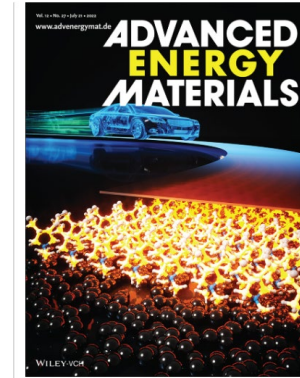
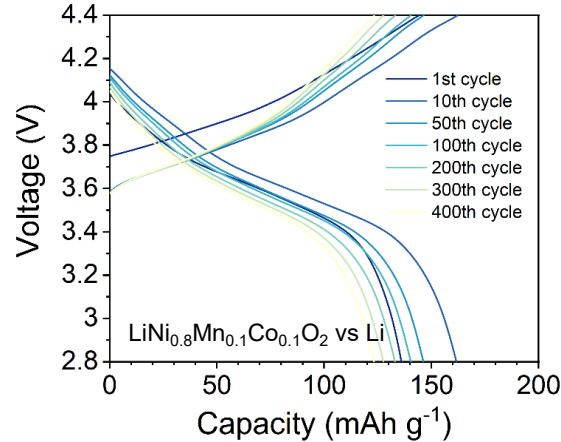
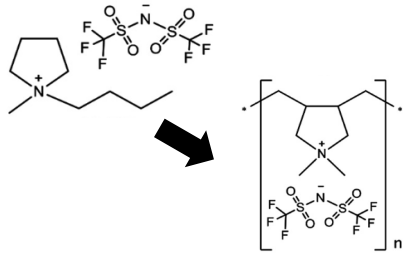
# Solid-state batteries



Duchène et al. EP 18205162

- Solid electrolyte based on hydroborate salts
- Built-in interface passivation functionality
- 78% capacity retention after 800 cycles
- Patented infiltration process

# Solid-state batteries



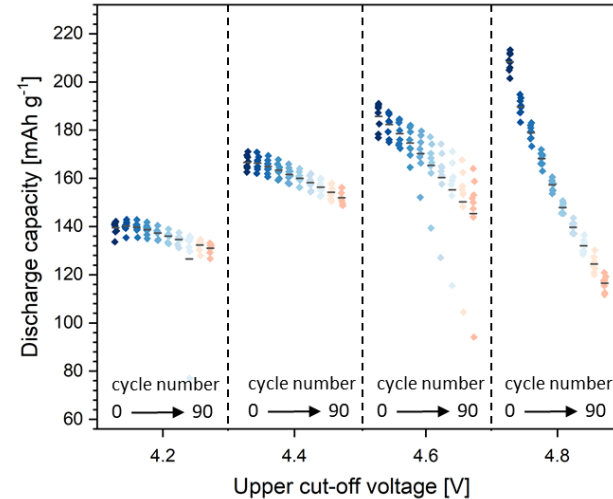
Fu et al. Adv. Energy Mater. 2022, 2200412

- Solid electrolyte based on polymerized ionic liquids
- Enables solid-state lithium metal batteries with > 1000 Wh/l
- 72% capacity retention after 600 cycles



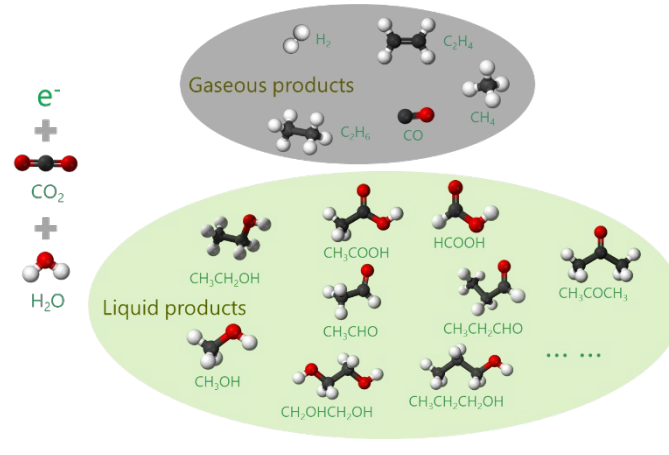
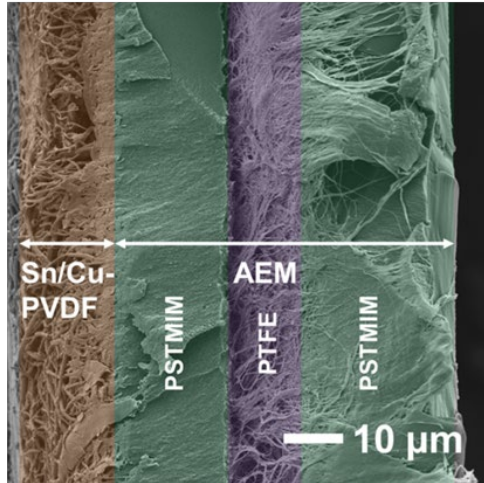
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875557

# Towards autonomous materials discovery



- Robotic platform for automated electrolyte formulation, cell assembly, and cell cycling
- Automated digital workflow and data management infrastructure

# Synthetic fuels from renewables



**Bientôt des carburants  
verts pour l'aviation?**

Publié 25 février 2021, 14:05



Une initiative entre deux prestigieux instituts a débuté pour développer une méthode de fabrication d'un substitut de kérosène, à partir de ressources renouvelables. Ce carburant pourra convenir aux avions.

- Electrocatalytic CO<sub>2</sub> reduction
- Fiber-based gas diffusion electrodes
- Understand product selectivity
- Enhance C<sub>2</sub>H<sub>4</sub> product yield

# From science to market

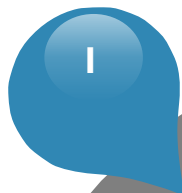
Li-ion  
batteries  
(Gen3b)



Solid-state  
batteries  
(Gen4)

Green  
batteries  
(GenX)

Synthetic fuels  
for long distance  
and long time scale



TRL

SNSF, SFOE, InnoSuisse  
ETH Board, Horizon Europe,  
Metrohm and Göhner Foundation

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