Empa
Materials Science and Technology

Aktuelle Trends in der Batterieforschung

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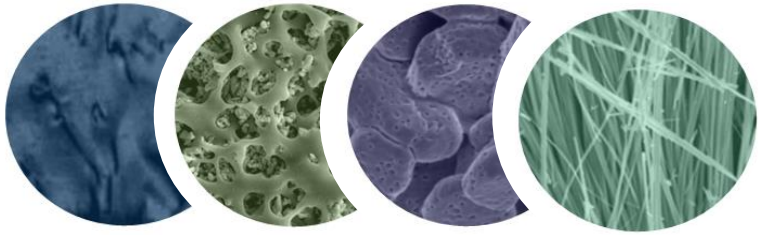
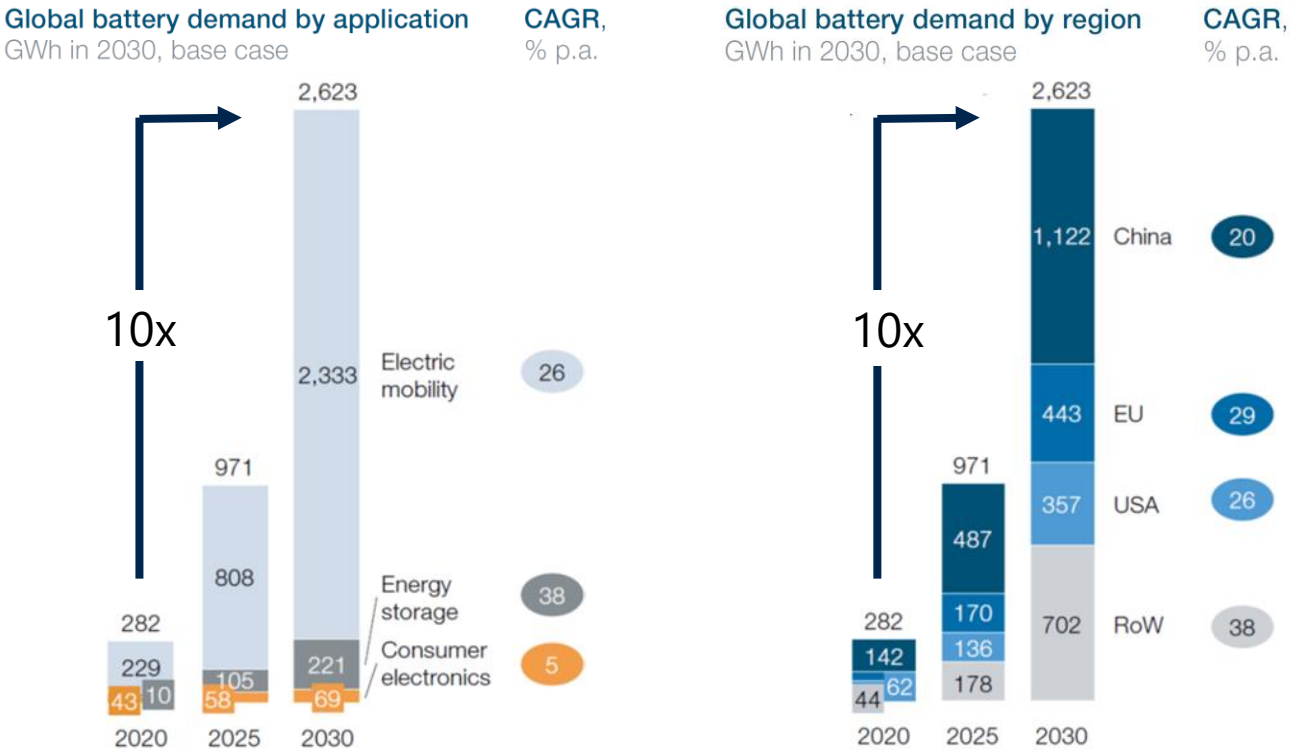


Society of Automotive Engineers Switzerland
October 29, 2020

Global battery demand



adapted from World Economic Forum Global Battery Alliance

European large-scale battery initiative

"We have to move fast because here we are in a global race. We need to prevent technological dependence on competitors."

"If we act together across Europe, we can capture an emerging battery market of Euro 250 billion per year."

Maroš Šefčovič
Vice-President European Commission

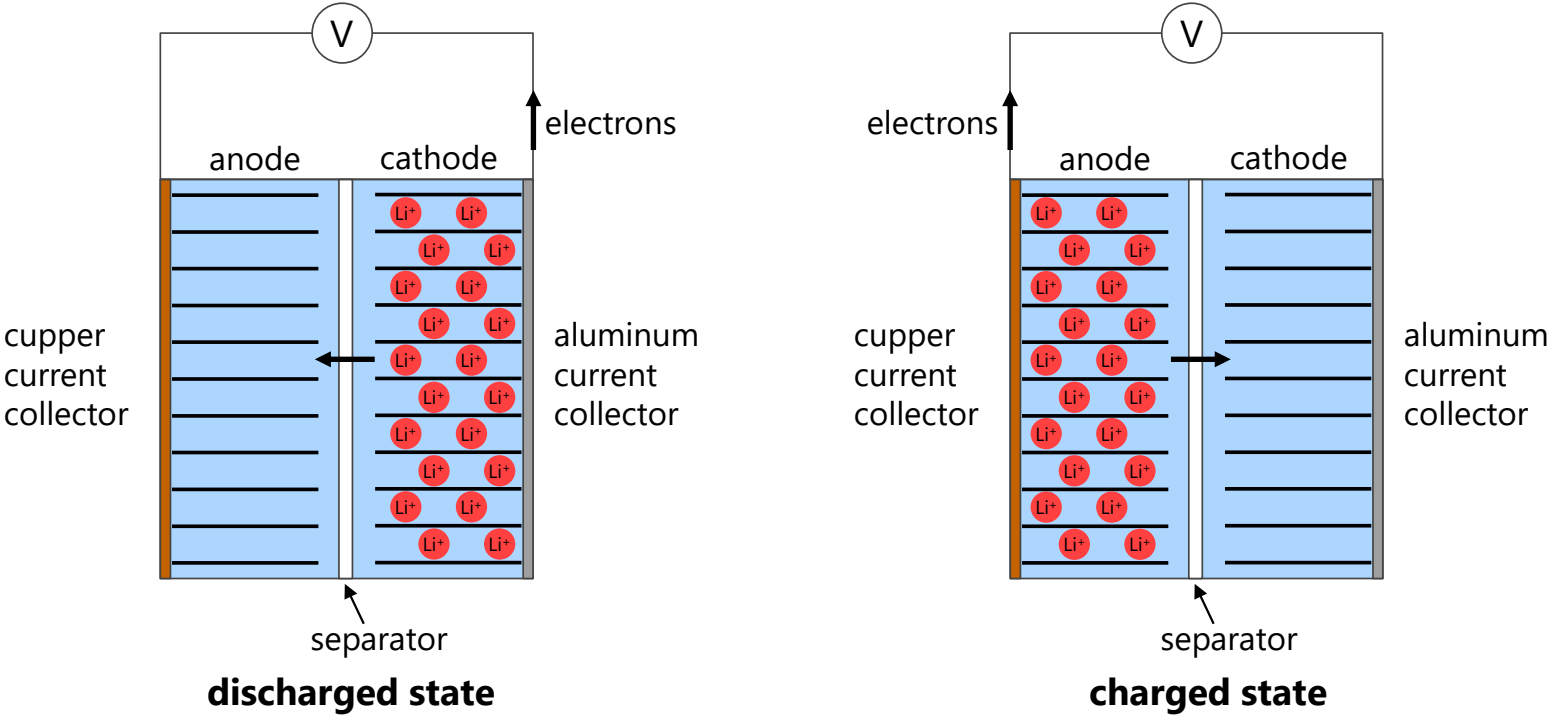
BATTERIES EUROPE
EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM

European Battery Alliance

BATTERY 2030+

www.battery2030.eu

Key components of a lithium-ion battery

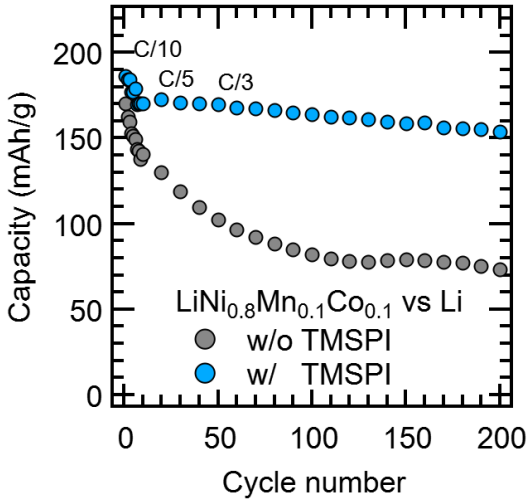


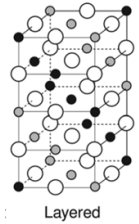
Active materials: Anode: **graphite**; Cathode: **transition metal oxides** like $LiNi_xMn_yCo_zO_2$

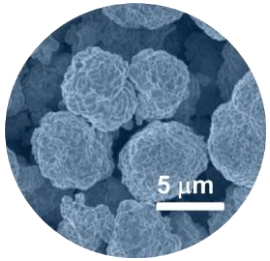
Reduce cobalt in cathode

Half reaction					potential
Li^{+}	+	$1e^{-}$	⇋	Li	-3.05 V
Na^{+}	+	$1e^{-}$	⇋	Na	-2.71 V
Fe^{2+}	+	$2e^{-}$	⇋	Fe	-0.44 V
Ni^{2+}	+	$2e^{-}$	⇋	Ni	-0.25 V
$2H^{+}$	+	$2e^{-}$	⇋	H_2	0.00 V
Mn^{4+}	+	$1e^{-}$	⇋	Mn^{3+}	+0.19 V*
Fe^{3+}	+	$1e^{-}$	⇋	Fe^{2+}	+0.35 V**
Co^{4+}	+	$1e^{-}$	⇋	Co^{3+}	+0.74 V*
Ni^{4+}	+	$1e^{-}$	⇋	Ni^{3+}	+0.77 V*
F_2	+	$2e^{-}$	⇋	$2\,F^{-}$	+2.87 V

(*-R 3 2'', **-P 2ac 2n, www.materialsprojects.org)







- Fluorine is the most oxidizing element
- 6200 Wh/kg vs 250 Wh/kg
- Nickel less stable than cobalt
- Stabilization through electrolyte additives

Vidal Laveda et al, ACS Appl. Energy Mater. 2019

SeNSE innovation chain at a glance

sense-battery.eu

Materials

- Silicon/graphite anode
- Nickel-rich cathode
- Safe electrolyte

Cell manufacturing

- Aqueous slurry processing
- Thermal electrode design
- In-cell sensors

Battery mgmt

- Cell formation
- Fast charging
- Adaptive algorithms

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JÜLICH Forschungszentrum | HELMHOLTZ-INSTITUTE MÜNSTER

Coventry University

AIT Austrian Institute of Technology

Solvionic

FPT Powertrain Technologies

LITHOPS BATTERIES

northvolt

enwires

HUNTSMAN
Enriching lives through innovation

Deliverables

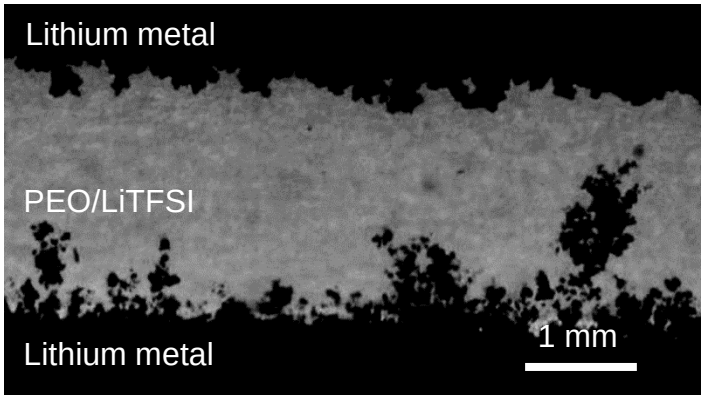
- 25 Ah prototype cells
- 1 kWh smart module
- Intellectual property

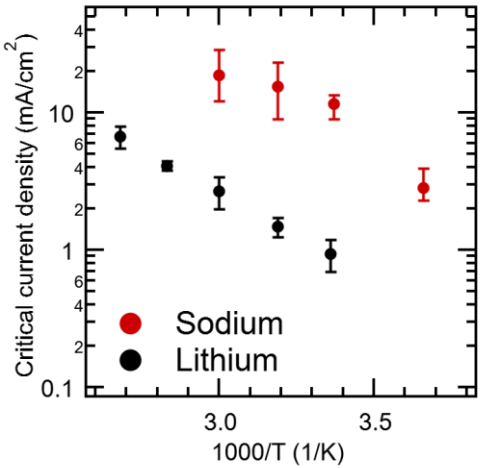
Impact

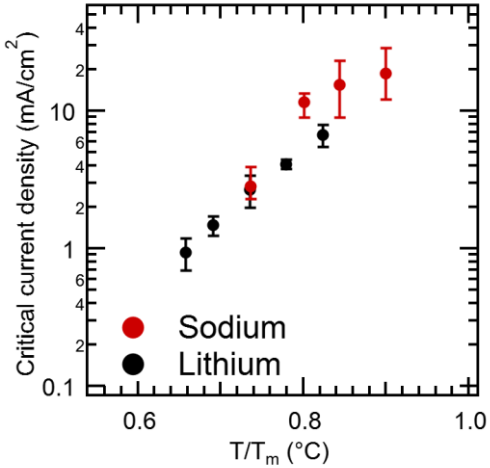
- Scalability
- Competitiveness
- Sustainability

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875548.

Eliminate dendrites in alkali metal anodes







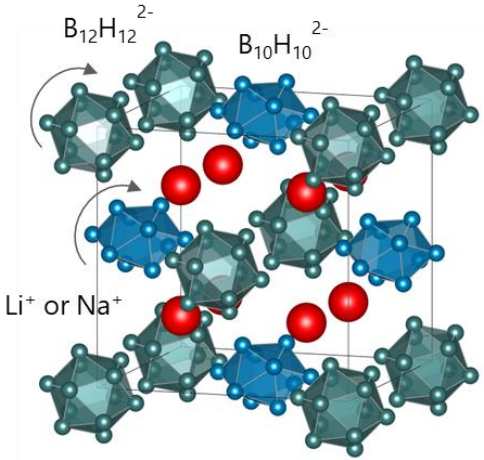
- Lowest potential, highest capacity
- Dendrites prevent fast charging
- 10x faster charging with sodium vs lithium
- Patented interface conditioning

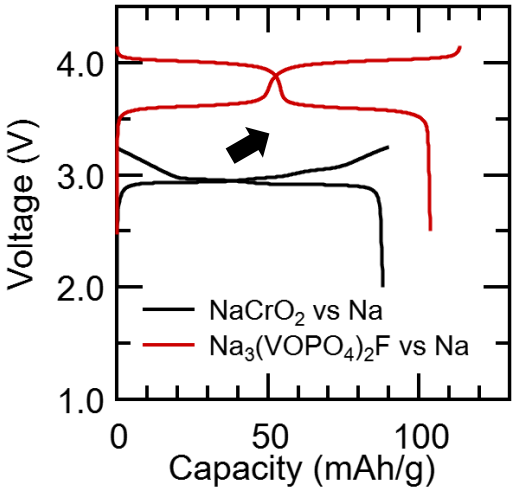
Fu et al. ACS Appl. Mater. Interf. 2020
Fu et al. EP 20141498.8 patent application
Grissa et al. in preparation

Bay et al. ACS Appl. Energy Mater. 2019
Bay et al. Adv. Energy Mater. 2019
Bay et al. US 16/560,229 patent application

Bay et al. Mater. Today Comm. 2020
Landmann et al. Mater. Today Energy 2020
Heinz et al. J. Power Sources 2020

Solid-state batteries





- Solid electrolyte based on hydroborates
- Built-in interface passivation functionality
- Best-in-class 4 V battery
- Patented infiltration process

Duchêne et al. Chem. Commun. 2017
Duchêne et al. Energy Environ. Sci. 2017
Yan et al. Adv. Energy Mater. 2017
Burankova et al. J. Phys. Chem. Lett. 2018
Duchêne et al. Energy Storage Materials 2019
Gigante et al. ChemSusChem 2019
Asakura ACS Appl. Energy Mater. 2019
Duchêne et al. Chem. Mater. 2019
Duchêne et al. Energy Storage Materials 2020
Payandeh et al. Chem. Mater. 2020
Duchêne et al. EP18205162 patent application
Payandeh et al. EP20189083.7 patent application

Conclusions

- Lithium-ion batteries dominate key markets due to balanced properties in terms of energy density, cycle life, safety, and costs
- Mature technology ➔ expect incremental improvements
- Solid-state batteries with metal anodes could double the energy density, however, major technical challenges remain
- Announcements of “breakthroughs” should be critically questioned

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