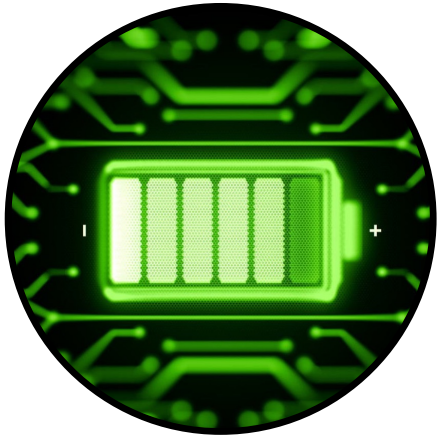
CENTRE FOR ENERGY INNOVATION | UNIVERSITY OF TWENTE.



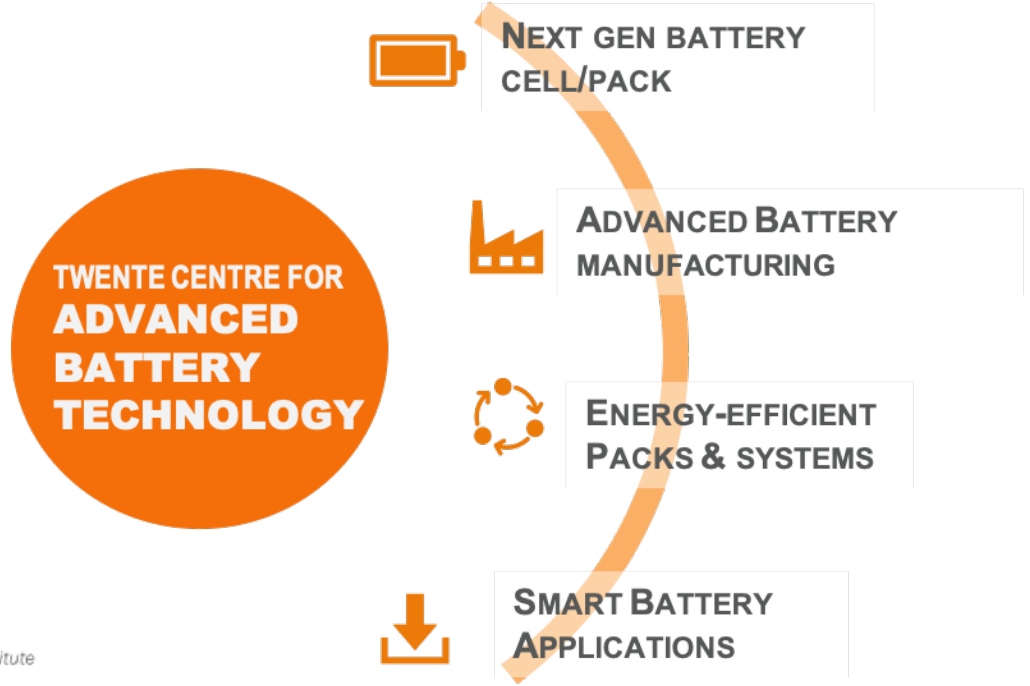
Twente Centre for Advanced Battery Technology

Prof. dr. ir. Mark Huijben

www.utwente.nl/tcabt

TWENTE CENTRE FOR **ADVANCED BATTERY TECHNOLOGY**

- 25 research groups
- full battery value chain
- ~ 100 researchers
- many industrial partners
- member of (inter)national battery R&D&I networks



BEPA Batteries European Partnership Association

ALISTORE European research institute

BATT4EU Batteries European Partnership

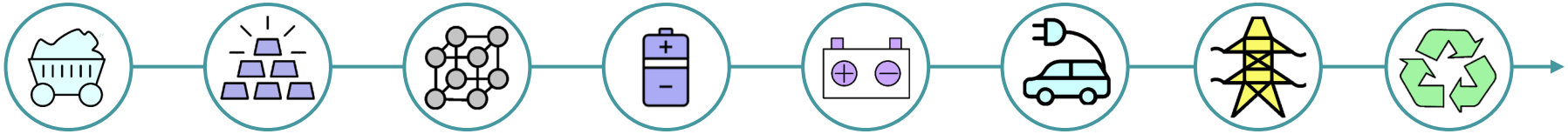
destiNY Doctorate programme on Emerging battery Storage Technologies INspiring Young scientists Marie Skłodowska-Curie actions COFUND PhD

BatteryNL Dutch Battery Materials

Holland High Tech
Global Challenges, Smart Solutions

TWENTE CENTRE FOR **ADVANCED BATTERY TECHNOLOGY**

- **Integral approach:** UT competences contribute to batteries challenges all along the value chain, multidisciplinary
- Accelerate the pace of impact with **mission driven roadmaps** together with our partners



Raw material mining | Raw material refining | Battery material | Cell production | Battery Pack + BMS | Primary application | Grid Storage or second use | Recycle

Metallurgy

Mineral exploration

Material Sc

Metallurgy

Mechanical Design

Safety

Power Electronics

Digital /Software

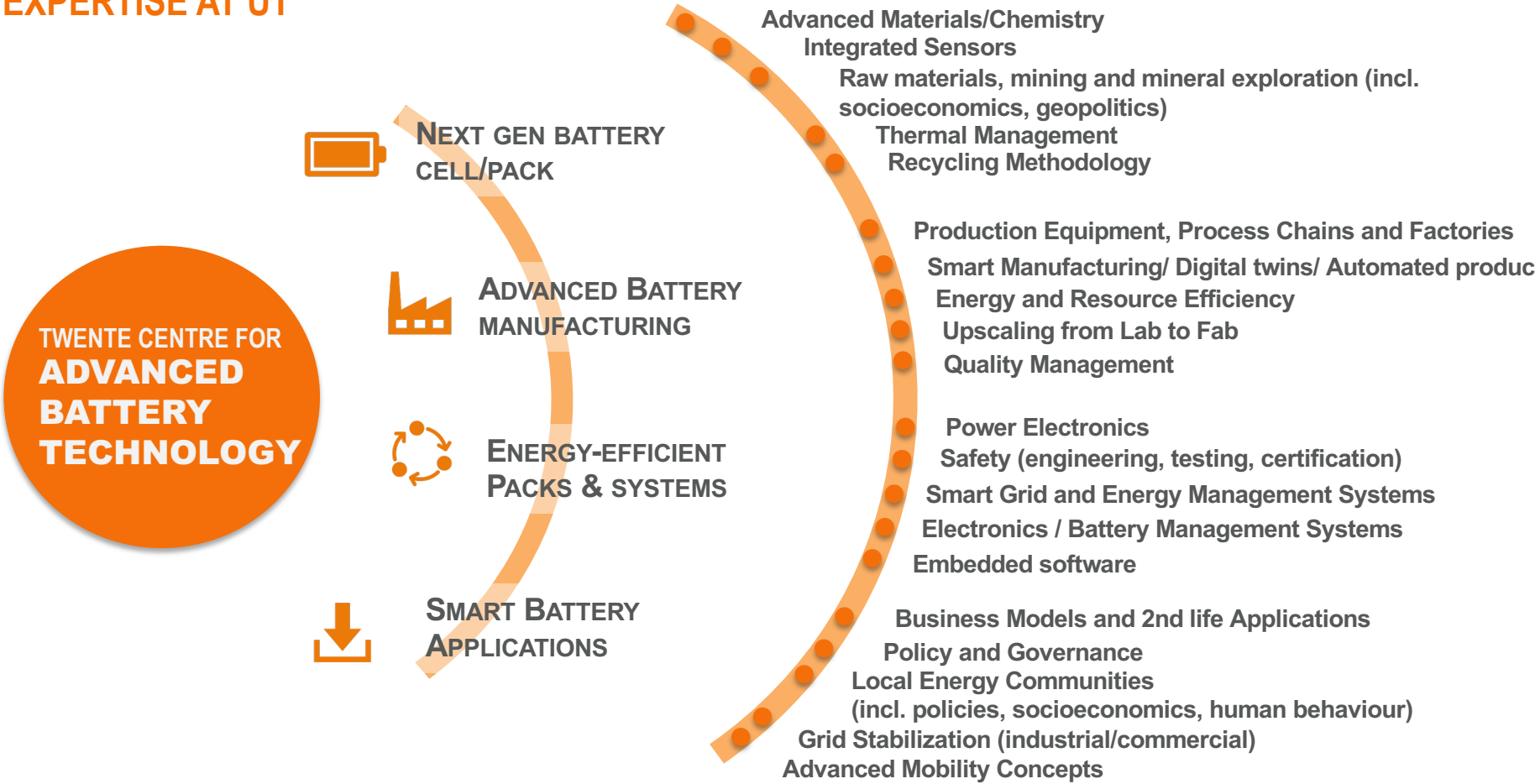
Electrical

Advanced Manufacturing

Policy/ Socioeconomics/ Behaviour

Life Cycle Analysis and Optimization

EXPERTISE AT UT



STRATEGY & ORGANISATION

Strategic Focus Points	**Next gen. materials & cells**	**Advanced manufacturing**	**Energy-efficient packs & systems**	**Smart applications**
Organisation	PI: Mark Huijben *(Fac. TNW)*	PI: Sebastian Thiede *(Fac. ET)*	PI: Prasanth Venugopal *(Fac. EEMCS)*	PI: Maarten Bonnema *(Fac. ET)*
	business development: Dirk van Asseldonk			
	>100 multidisciplinary researchers from 4 different UT faculties in project driven activities			
	Hosted by: Centre for Energy Innovation (SBD) & MESA+			
Infrastructure	**Equipment for material processing and characterization**	**Pilot lines for cell and pack manufacturing**	**Test facilities for lab/industrial cells and packs**	

Regional battery industry (examples)

Battery systems

VDL ENERGY SYSTEMS

Sensata Technologies

THALES

nedap

DEMCON

Elaadnl

SUPER B lithium batteries

E-bikes

vanraam Let's all cycle

THE PREMIER EUROPEAN CYCLE GROUP

ACCELL GROUP

BREKR

Heavy duty

HENCON

Contour

Bredenoord

Recycling

RIWALD recycling

Materials analysis

Malvern Panalytical a spectris company

Battery testing

DNV

CESI

KEMA Labs

TWENTE SAFETY CAMPUS

Battery Safety Lab

Destructive testing of battery systems for (fire)safety up to 100 kWh

CROSS-BORDER BATTERY PROGRAM

EUREGIO

Enschede

Münster

CROSS-BORDER BATTERY PROGRAM

VDL ENERGY SYSTEMS

DEMCON

SUPER B lithium batteries

DNV

TWENTE SAFETY CAMPUS

UNIVERSITY OF TWENTE.

TWENTE CENTRE FOR ADVANCED BATTERY TECHNOLOGY

MESA+ INSTITUTE

FRAUNHOFER INNOVATION PLATFORM

WWU MÜNSTER

meet

HI MS HELMHOLTZ-INSTITUTE MÜNSTER

FFB
Open Innovation Lab

Fraunhofer IPT

RWTH AACHEN UNIVERSITY

JÜLICH Forschungszentrum

COOPERATION **FFB MUNSTER** WITH **UT/FIP ENSCHEDE**

Research Fab Battery Cells (Forschungsfertigung Batteriezelle – FFB) in Münster/Germany

Fraunhofer Innovation Platform (FIP) at the University of Twente in Enschede/the Netherlands

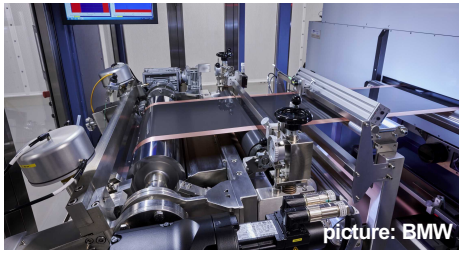
Fraunhofer
FFB

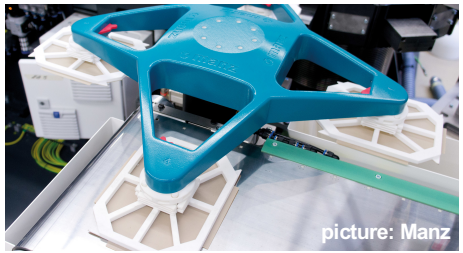
Fraunhofer-Einrichtung Forschungsfertigung
Batteriezelle FFB

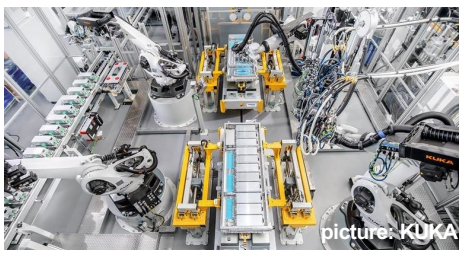
UNIVERSITY
OF TWENTE.

FRAUNHOFER
INNOVATION PLATFORM
FOR ADVANCED MANUFACTURING

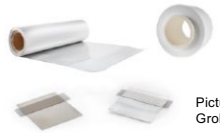
COOPERATION **FFB MUNSTER** WITH **UT/FIP ENSCHEDE**



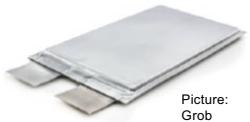




Electrode Production	Cell Assembly	Formation/Finishing	Module/pack assembly
Mixing, Coating, Drying, Calendaring	Stacking, drying, can cutting forming, electrolyte filling, sealing (takes place in dry room)	Electro-chemical activation and testing	Assembly of cells and further components to modules, contacting
continuous/batch process	discrete manufacturing	batch process in test/charging rigs	discrete manufacturing



Picture:
Grob

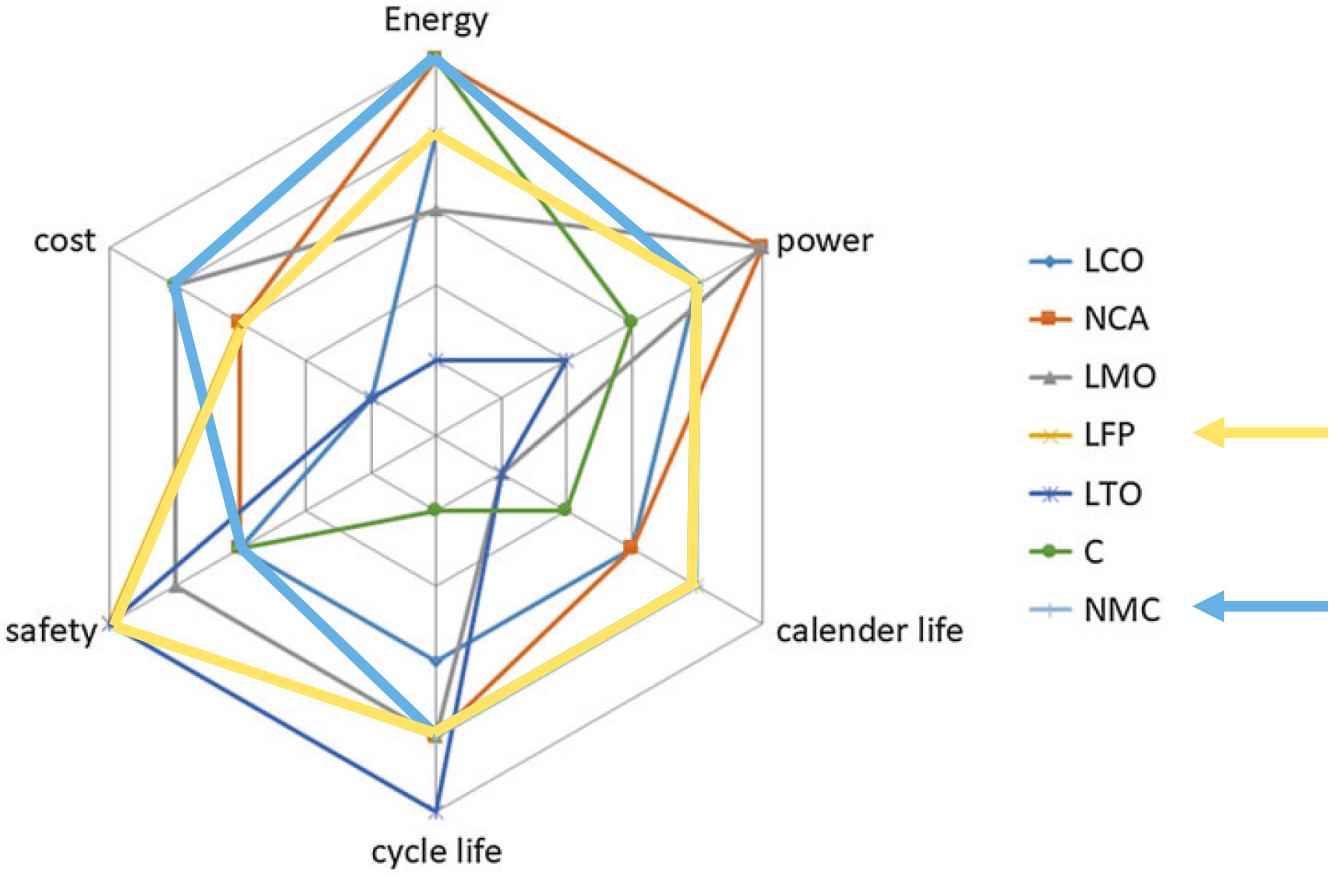


Picture:
Grob

Source:
AUDI AG

Lithium-ion Batteries

Lithium-ion Batteries

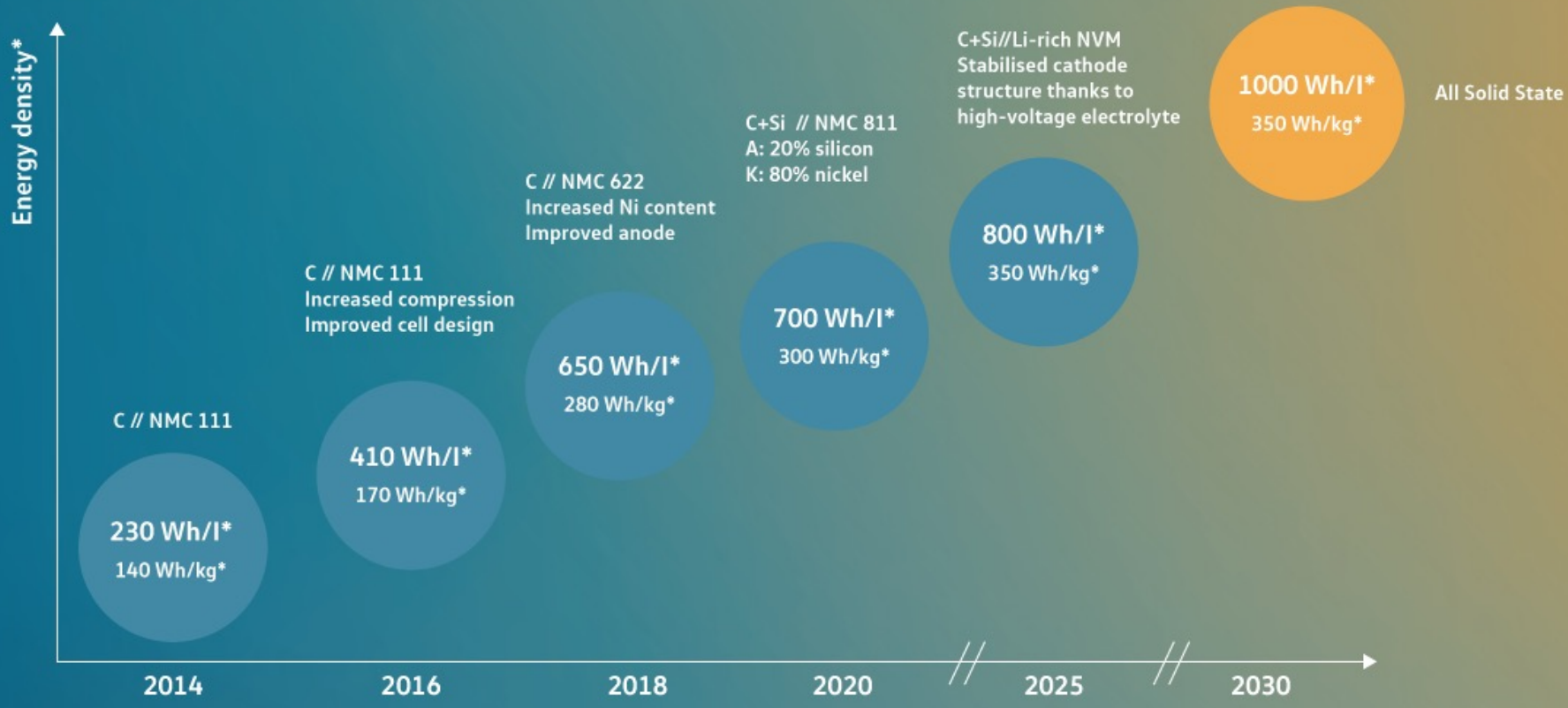


Global Battery Roadmap

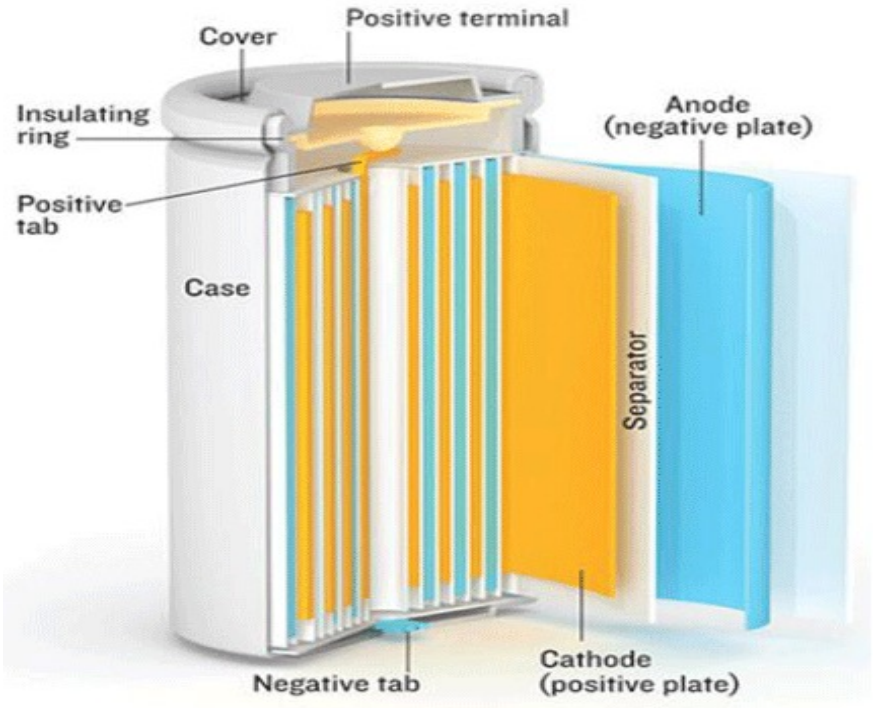
Cell generation	Cell chemistry
Generation 5	• Li/O_2 (lithium-air)
Generation 4	• All-solid-state with lithium anode • Conversion materials (primarily lithium-sulphur)
Generation 3b	• Cathode: HE-NCM, HVS (hight-voltage spinel) • Anode: silicon/carbon
Generation 3a	• Cathode: NCM622 to NCM811 • Anode: carbon (graphite) + silicon component (5-10%)
Generation 2b	• Cathode: NCM523 to NCM622 • Anode: carbon
Generation 2a	• Cathode: NCM111 • Anode: 100% carbon
Generation 1	• Cathode: LFP, NCA • Anode: 100% carbon

Development of the lithium-ion technology

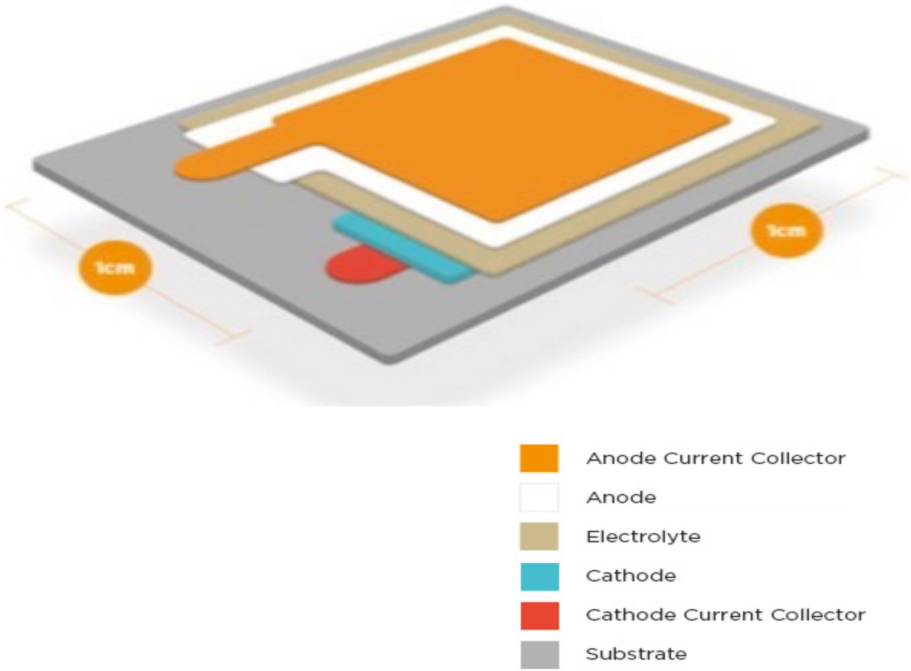
Volkswagen



Conventional battery



Solid-state battery



Challenges Materials / Chemistry :

Enhanced performance
- Energy density
- Charging rate
- Life time
- Safety

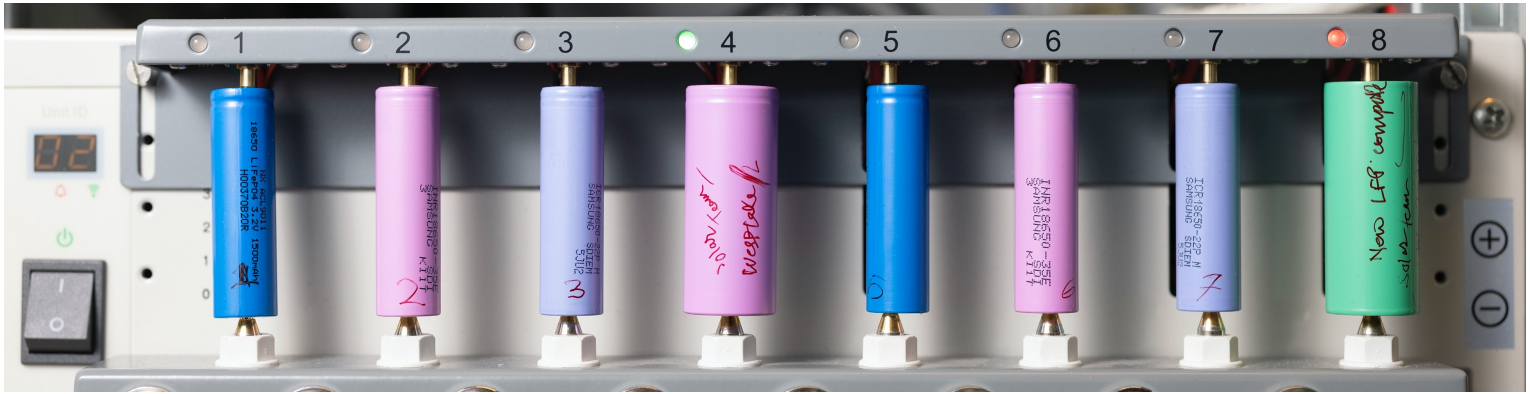
Materials / Chemistry:
- Earth abundant elements
- Recyclable
- Energy efficient
- Low cost

Research focus:
- Materials discovery (experiments and theory)
- Degradation analysis (operando characterization)
- Interface engineering (e.g. advanced coatings)
- Innovative battery design (e.g. 3D vs. 2D)

Applied Research (with industrial partners)

- Materials development and characterisation

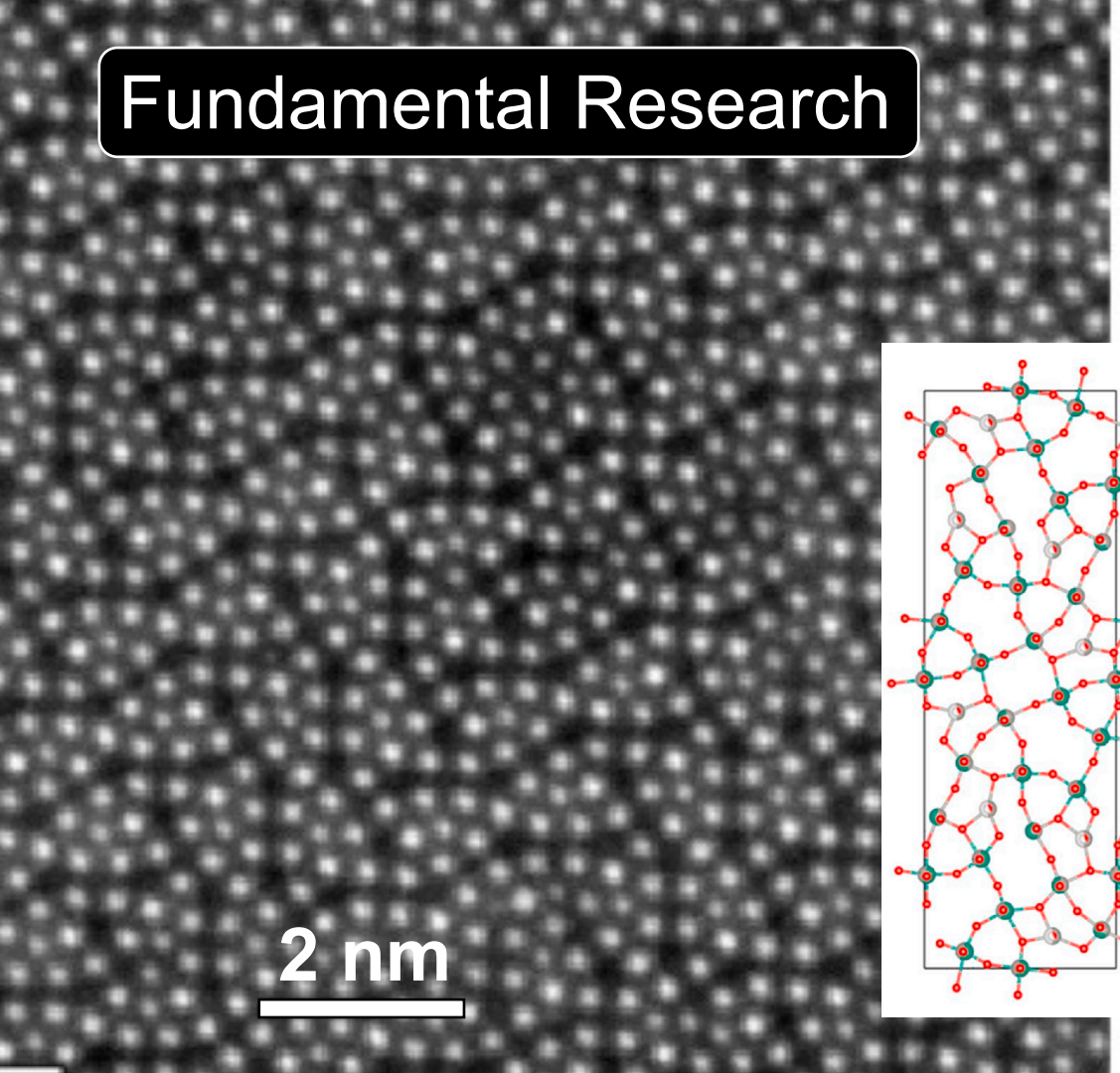
- Battery cell analysis

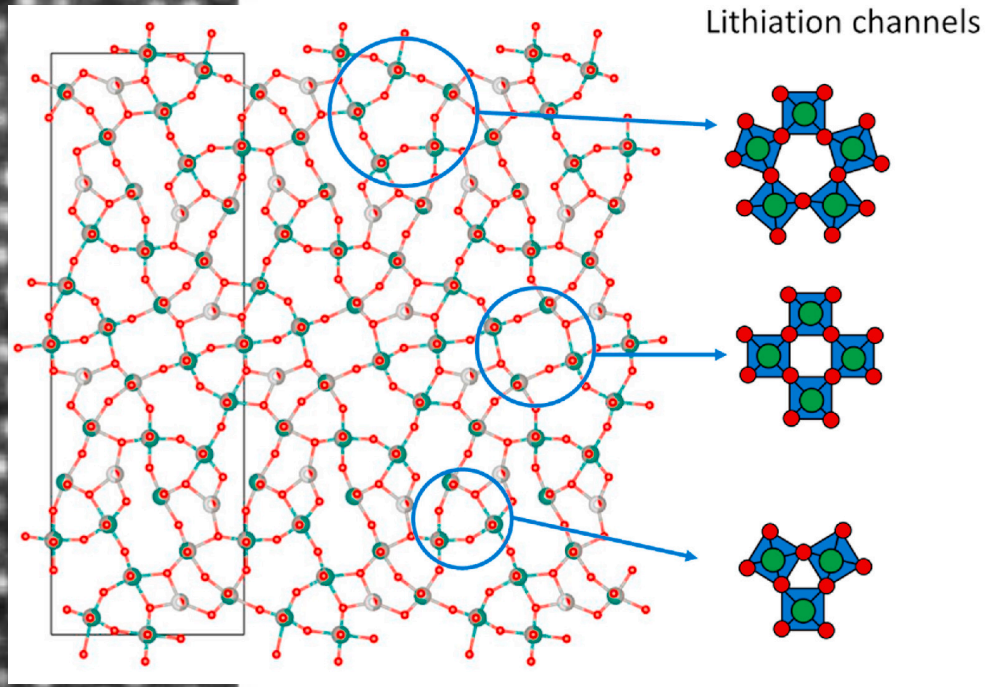


Fundamental Research

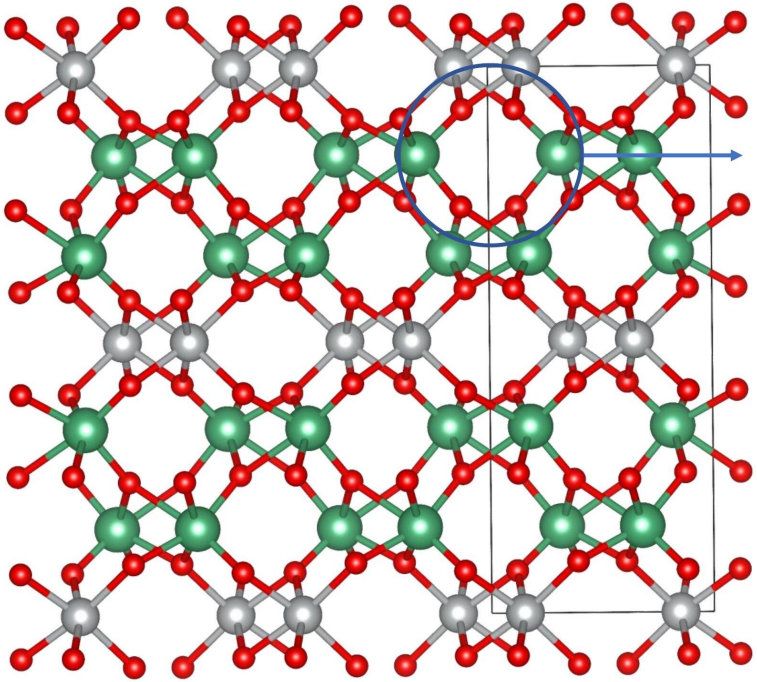
Fast charging anode

$Nb_{18}W_{16}O_{93}$





$NiNb_2O_6$ as fast charging anode

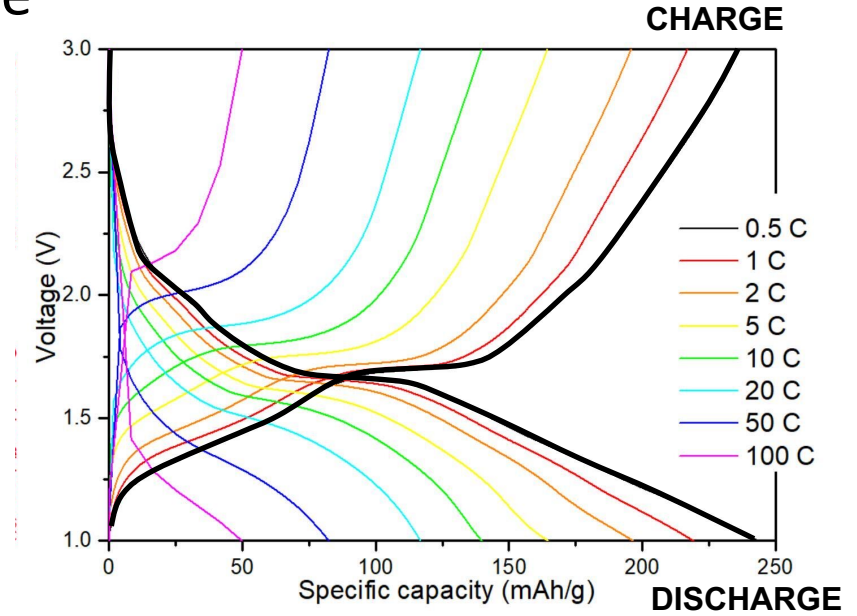


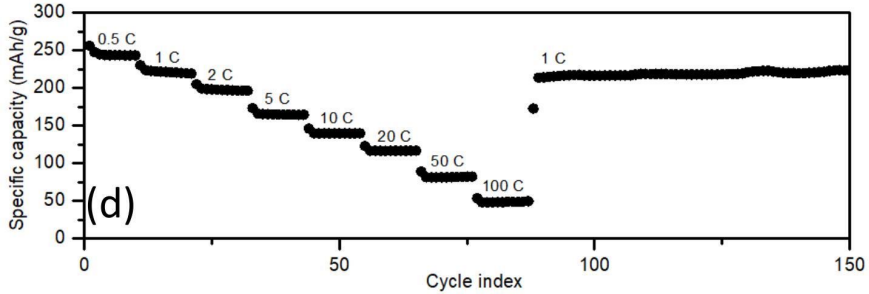
Single type of channel for lithium diffusion

O

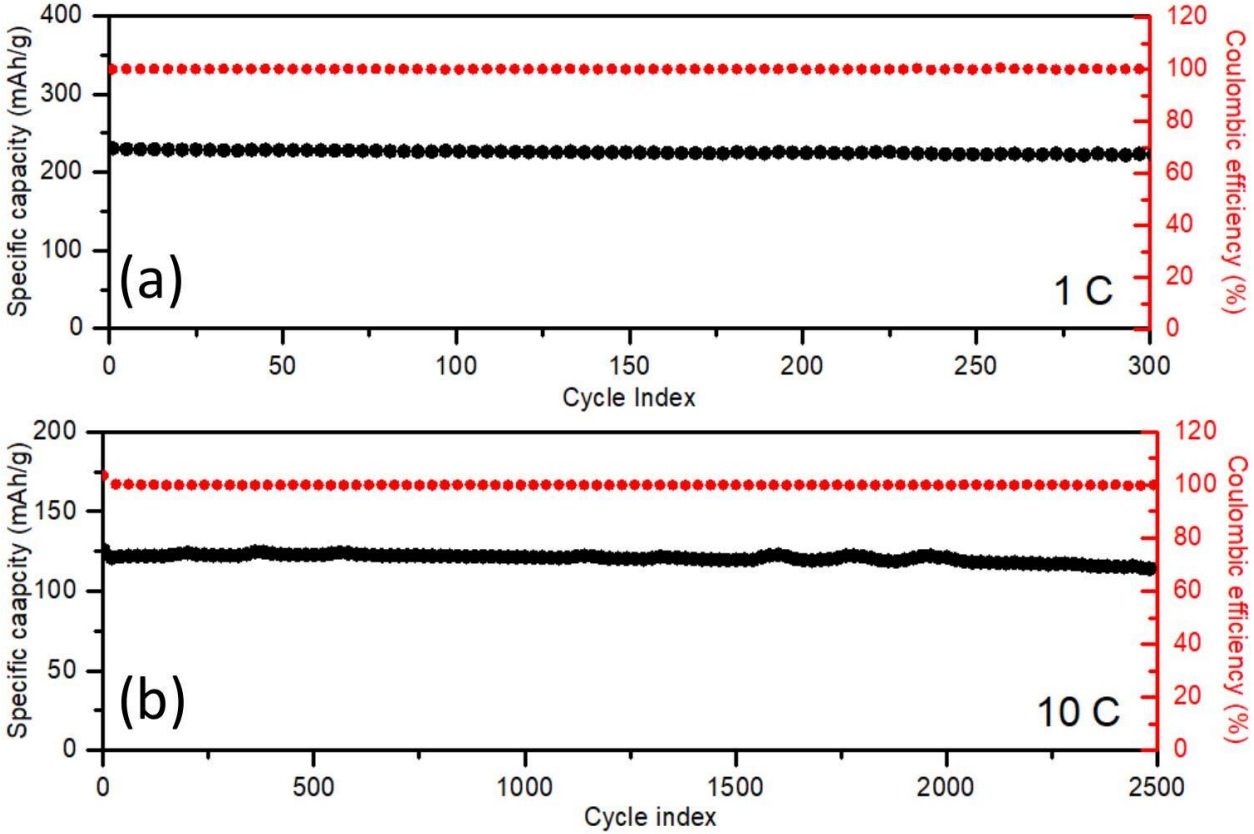
Nb

Ni



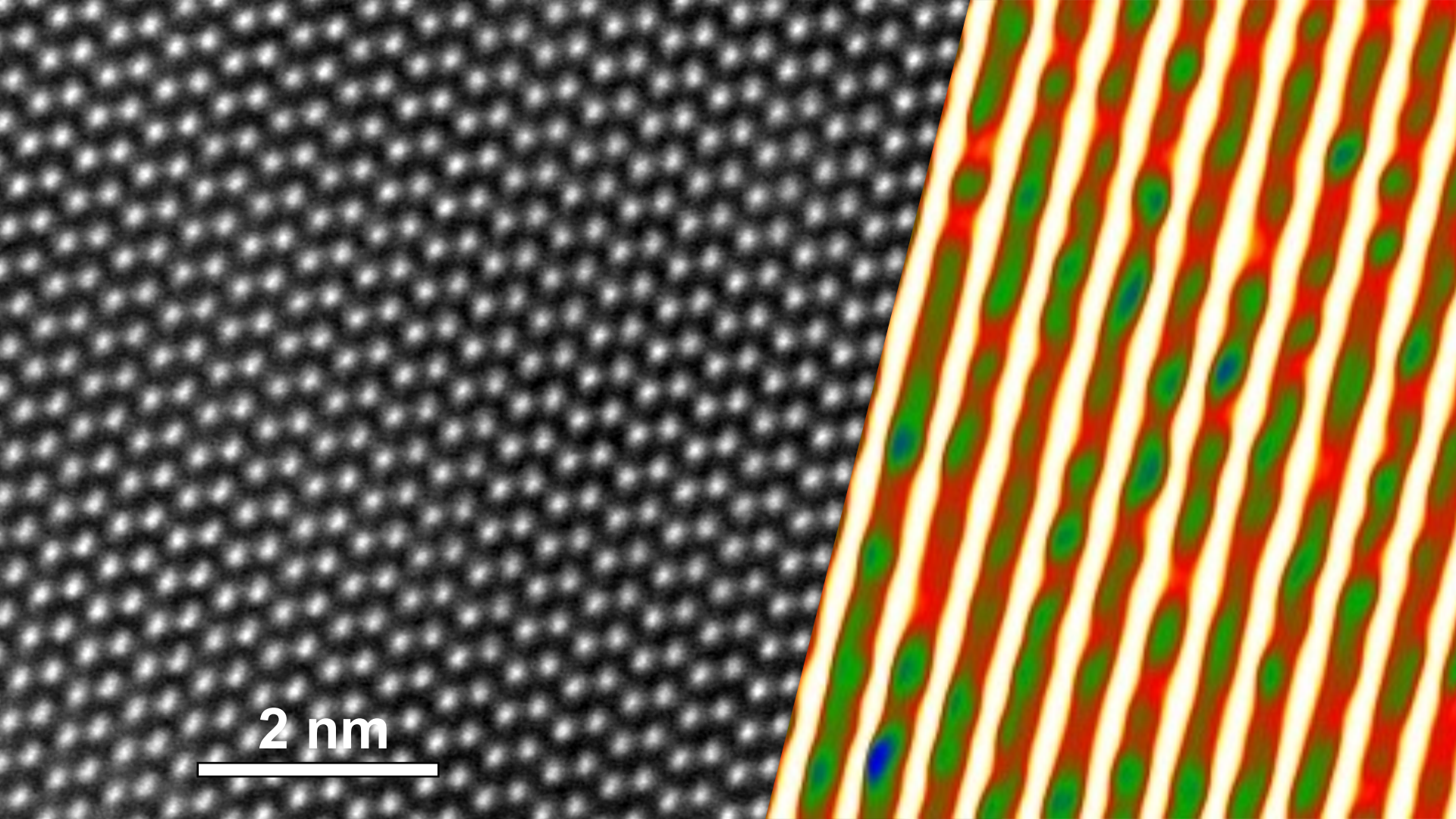


$NiNb_2O_6$ as fast charging anode

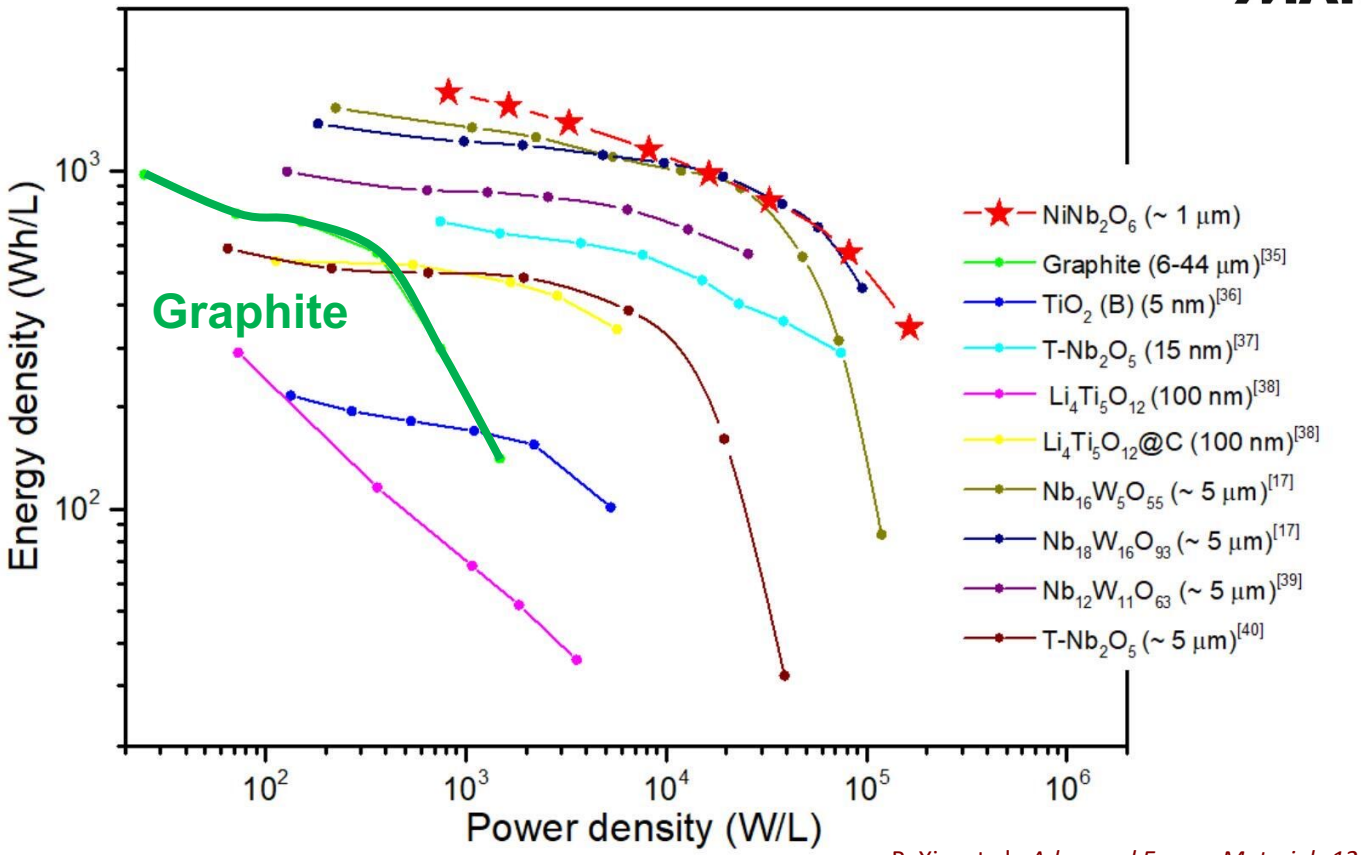


Full charge in 1 hour

Full charge in 6 min.


2 nm

Energy vs. Power : rate performance



R. Xia, et al., *Advanced Energy Materials 12, 2102972 (2022).*

Dutch National Science Agenda

National research program on battery materials

DUTCH NATIONAL BATTERY MATERIALS RESEARCH PROGRAM

BatteryNL
Dutch Battery Materials

National Science Agenda, 8 years, 10 MEuro

Knowledge partners

- 5 universities
- 5 universities of applied sciences
- TNO – Holst Centre
- TNO – ECN
- MEET Munster
- Forschungszentrum Julich

AUTOMOTIVE INDUSTRY NL

InnoEnergy

Energy Storage NL

POWERED BY DUTCH TECHNOLOGY

New Energy Coalition

anwb

STEDIN NET

SOLVIS

LEYDEN JAR TECHNOLOGIES

durapower

LionVolt

Shell

VDL

DNV·GL

SOLMATES

Air Liquide

LithiumWerks
New Energy. New World.

vsparticle

SALDtech

E-magy
by RGS development

DelftIMP

euro support

PTG EINDHOVEN

Battery manufacturing

National Growthfund research consortium

NXTGEN Hightech Equipment

Application domain ‘Energy’

Next-gen equipment for batteries and battery materials :

- R&D projects
- Pilot lines
- Test facilities

Budget : ~ 60 M€

www.nxtgenhightech.nl

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TWENTE CENTRE FOR
ADVANCED BATTERY TECHNOLOGY
www.utwente.nl/tcabt

Thank you

Contact : m.huijben@utwente.nl