HYBRIS

Enhanced Hybrid Storage Systems

Lithium Titanate Batteries

Workshop on energy storage and its crucial role in the energy transition with focus on hybrid solutions

Presented by Fabio Muzio – Project Manager

BALCKE DÜRR ENERGY SOLUTIONS

- ☐ 1st HYBRIS Workshop
- ☐ Horcynus Orca Foundation, 23rd June 2022

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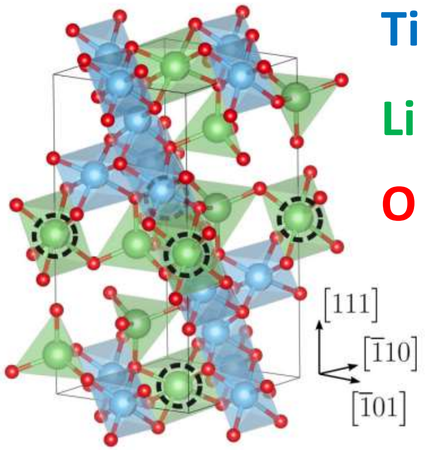
Overview & chemistries

Li-Battery system

LiB choice: **$Li_4Ti_5O_{12}$** (LTO)

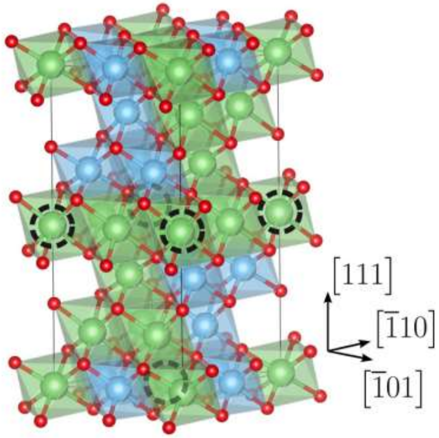
- **High cyclability** (**>20,000 cycles,** at 3C & 25°C)
- **High energy storage** capacity
- **High** charge/discharge **power** (up to 80% SOC in 6min, 50% SOC in 10s)
- **High round trip charge/discharge efficiency** (up to >92%)
- **Hinders dendrite formation**
- **Lower Co content** in cathode (partially substituted by Ni & Mn)
- **Very low combustion/burning risk** even at C rates > 3C
- **Long term maintenance free** also under heavy duty cycles

$$Li_4Ti_5O_{12} + 3e^- + 3Li^+ \rightarrow Li_7Ti_5O_{12}$$



Spinel structure **$Li_4Ti_5O_{12}$**

Rock-salt structure **$Li_7Ti_5O_{12}$**



Benedikt Ziebarth, PHYSICAL REVIEW B 89, 174301 (2014)

Incorporation of Li in anode host material results in a phase transition which has **"zero strain"** intercalation or zero change in volume (0.2%). As a result, no mechanical defects are induced compared to silicon or graphite anodes.

H2020
G.A. 963652

Main progress done in WP2 Tasks & Deliverables

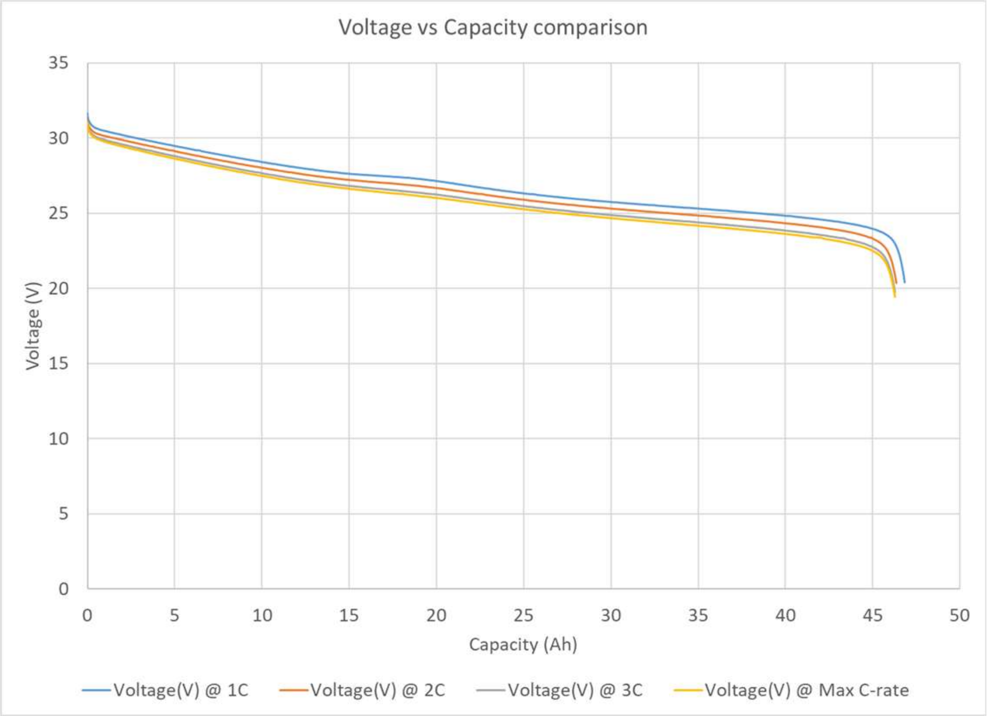
T2.2: Assessment of high-power battery module based on LiB

Consiglio Nazionale delle Ricerche

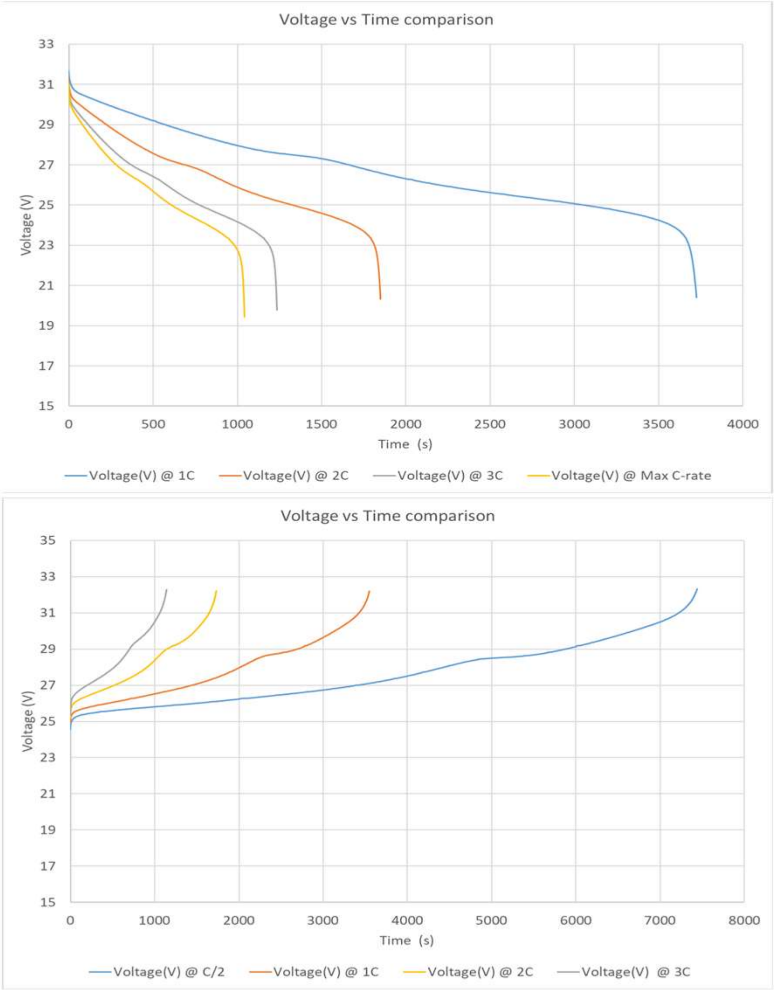
Module and cell tests and characterization performed:

- Various charge/discharge cycles until max continuous current
- Hybrid Pulse Power Characterization test for SoC-Voc relation
- Peak – shaving (power application)*
- Power quality (power application)*

Various charge/discharge cycles up to 3,5C 160A



The Li-battery works properly in the range of currents tested.
No major potential and capacity loses are observed.

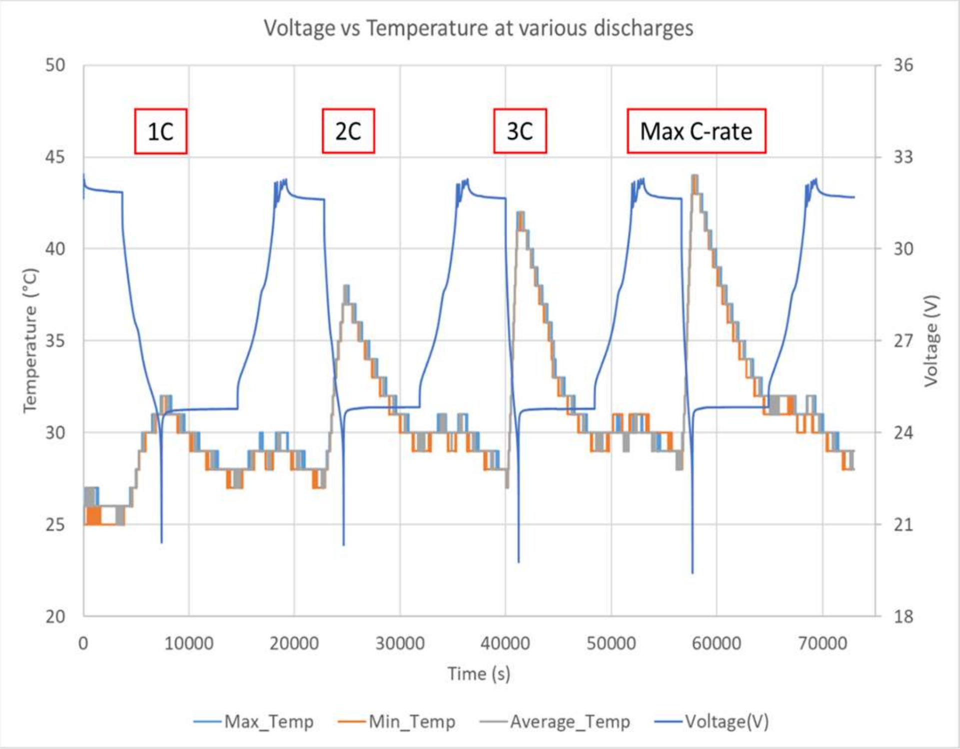


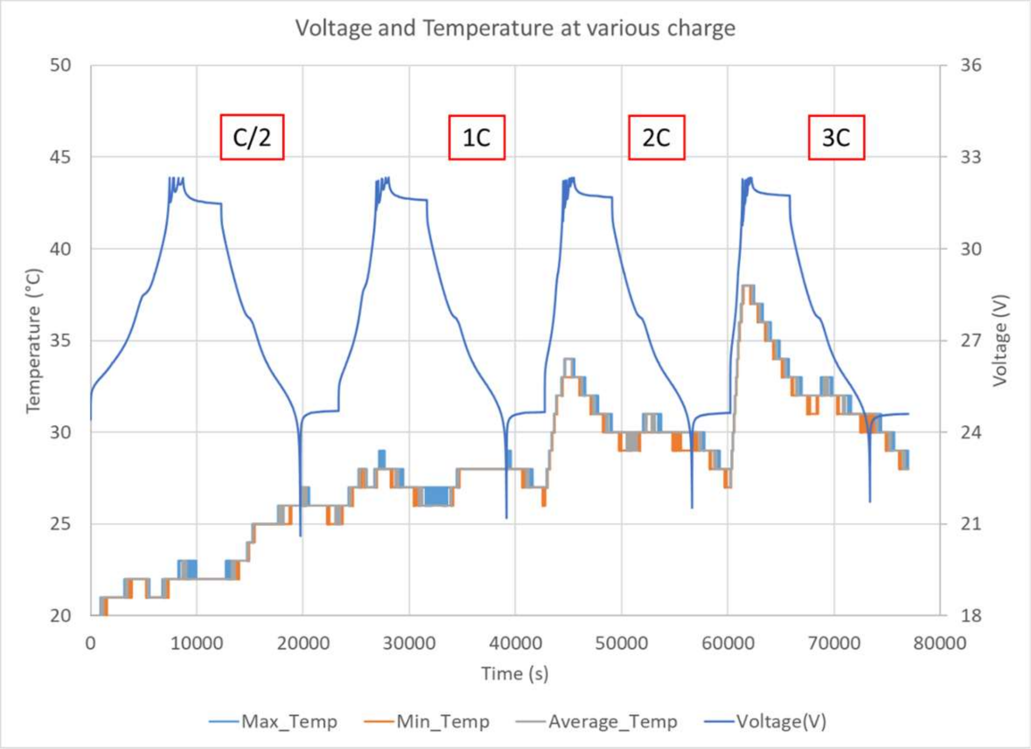
Galvanostatic voltage drop transients
for different c-rates

Main progress done in WP2 Tasks & Deliverables

T2.2: Assessment of high-power battery module based on LiB

Temperature measurements for different charge/discharge rates





C-rate	P (kW)	Ah discharged	Wh Discharged	Max temperature (°C)
1C	1,2	46,816	1253,4	32
2C	2,4	46,34	1221,8	38
3C	3,6	46,28	1201,95	42
160 A (3,5C)	4,2	46,28	1191,22	44

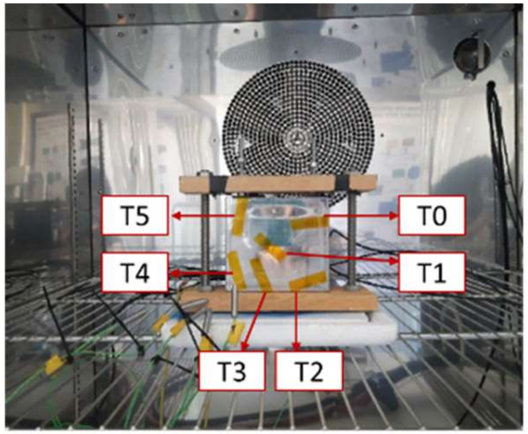
C-rate	P (kW)	Ah charged*	Wh charged*	Max temperature (°C)
C/2	0,6	46,09	1272,4	23
1C	1,2	44,07	1225,9	29
2C	2,4	43,11	1214,5	34
3C	3,6	42,72	1218,8	38

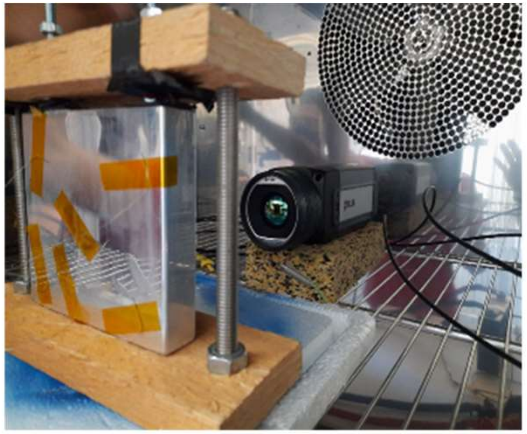
Fast charging implies a reduction of capacity (about 7% for 3C)

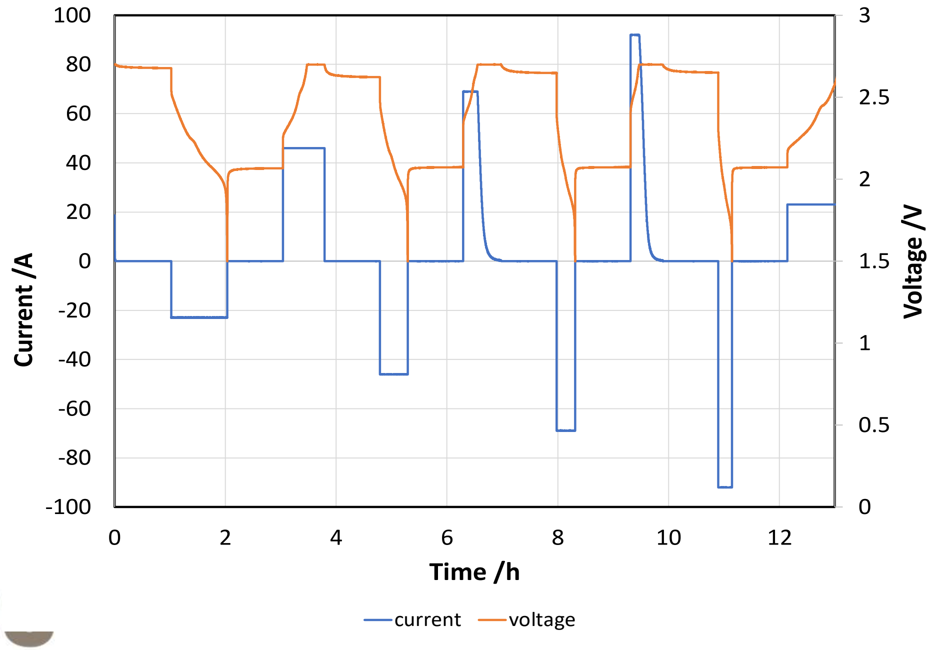
High rate discharge (above 3C) may require cooling system to enhance battery safety and life-time
Not discharging completely the battery (being within the 50-90% SoC) extends battery lifetime

Thermal management evaluation

Thermal testing of the LTO cell

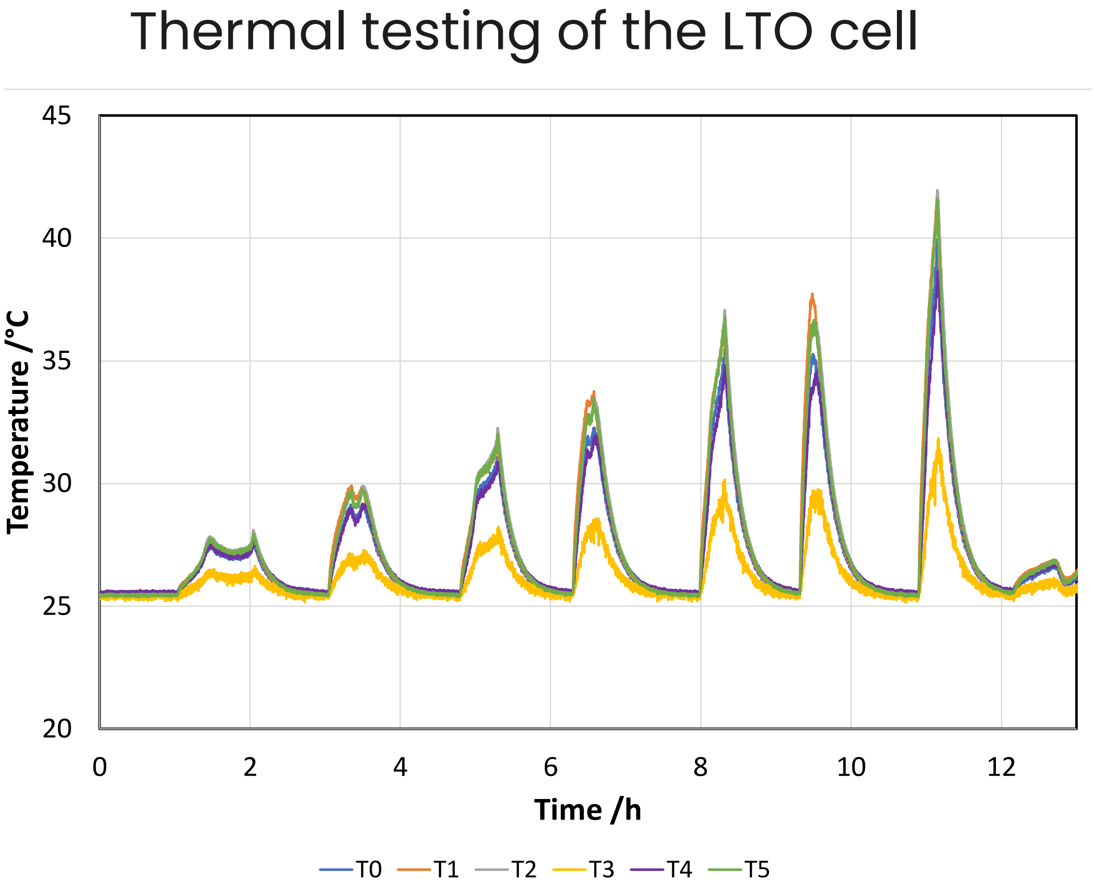






- Temperature measurement with K-type thermocouples and FLIR IR camera
- Procedure: the cell was fully charged at constant voltage until the current reached a value corresponding to a state of charge (SOC) 100%; then the current was maintained a 0A until the voltage reached the OCV value; finally, the cell was fully discharged at constant current until the voltage reached a value corresponding to 0%.

Thermal management evaluation



Results in a nutshell:

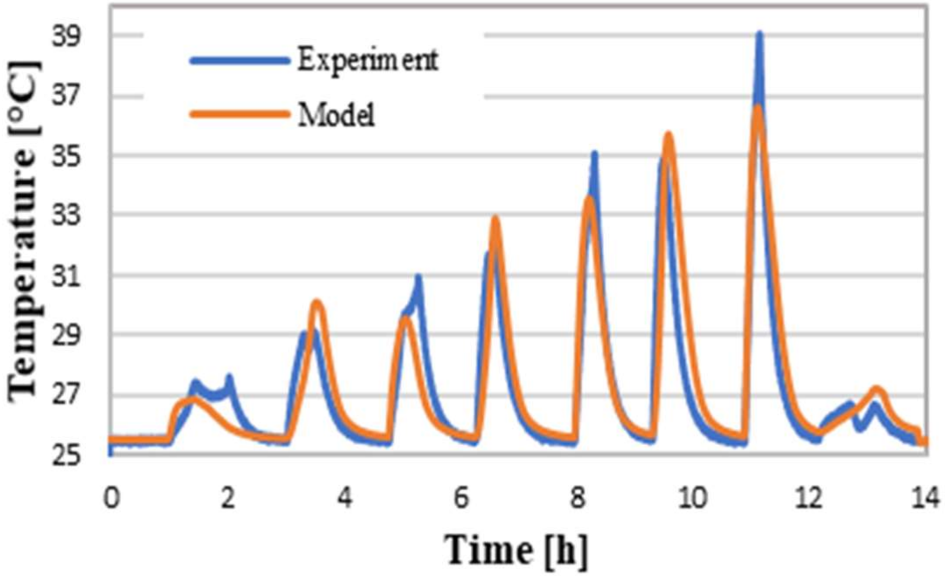
- temperature difference among the different points of the surface of the cell is within 1 K, thus indicating a good uniformity; there is a clear effect of the C-rate: at 1C, the max temperature reached by the cell does not exceed 30°C, for the charge at 4C a maximum temperature of 42°C is measured.
- the heating occurring during discharge is slightly more marked than during charge

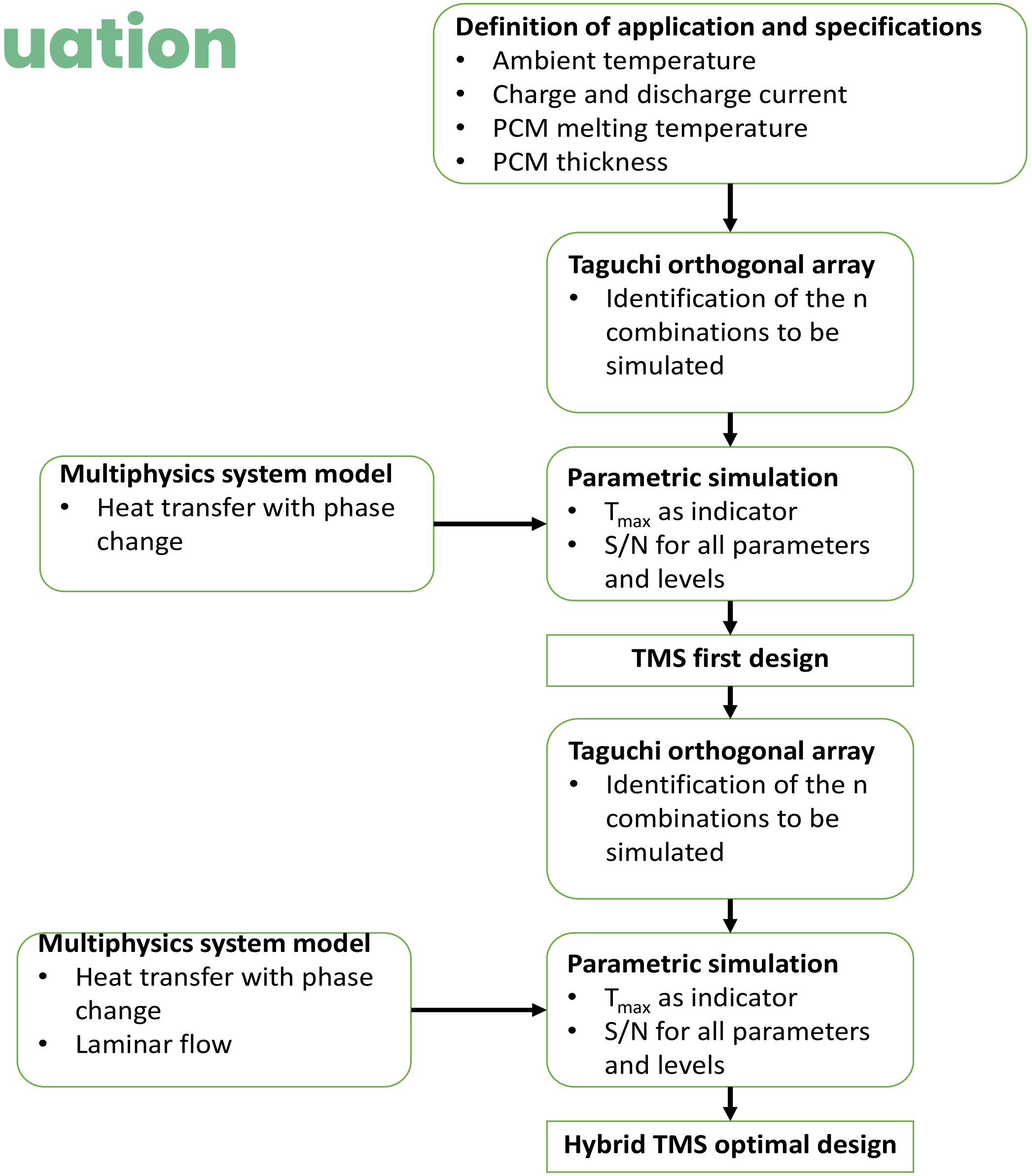
Main progress done in WP2 Tasks & Deliverables

T2.2: Assessment of high-power battery module based on LiB

Thermal management evaluation

A 3D model was developed in Comsol Multiphysics and validated with experimental results and used for evaluation of different management systems





Definition of application and specifications
- Ambient temperature
- Charge and discharge current
- PCM melting temperature
- PCM thickness

Taguchi orthogonal array
- Identification of the n combinations to be simulated

Multiphysics system model
- Heat transfer with phase change

Parametric simulation
- T_{max} as indicator
- S/N for all parameters and levels

TMS first design

Taguchi orthogonal array
- Identification of the n combinations to be simulated

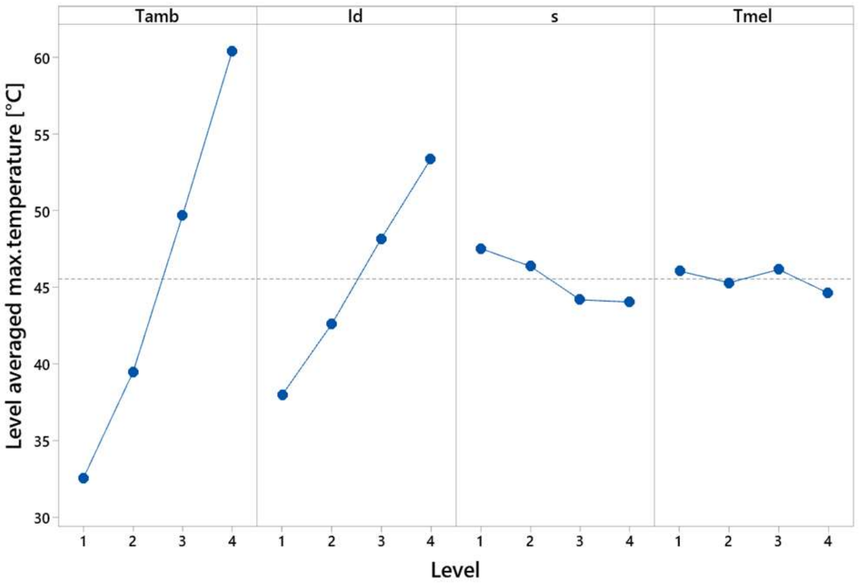
Multiphysics system model
- Heat transfer with phase change
- Laminar flow

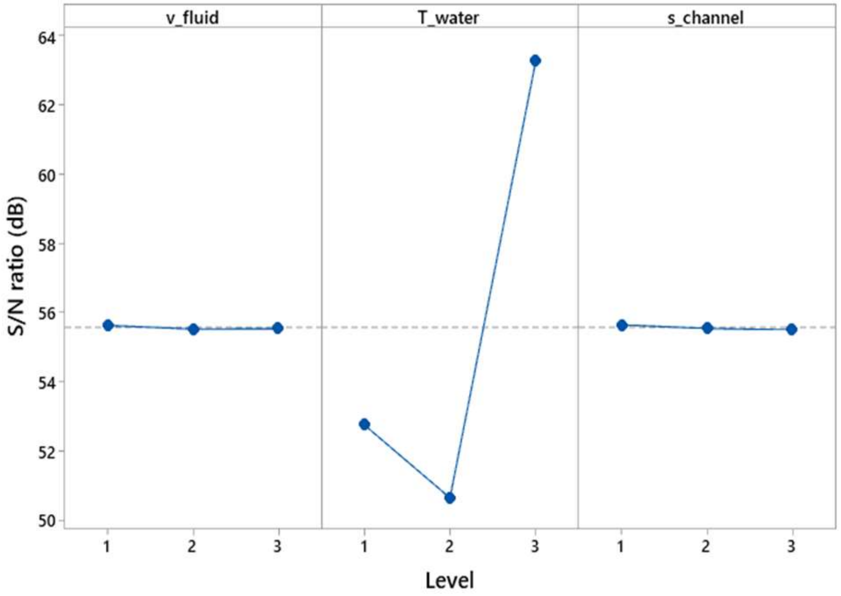
Parametric simulation
- T_{max} as indicator
- S/N for all parameters and levels

Hybrid TMS optimal design

Thermal management evaluation

Numerical model for thermal management analysis





Design factors for passive and hybrid thermal management systems

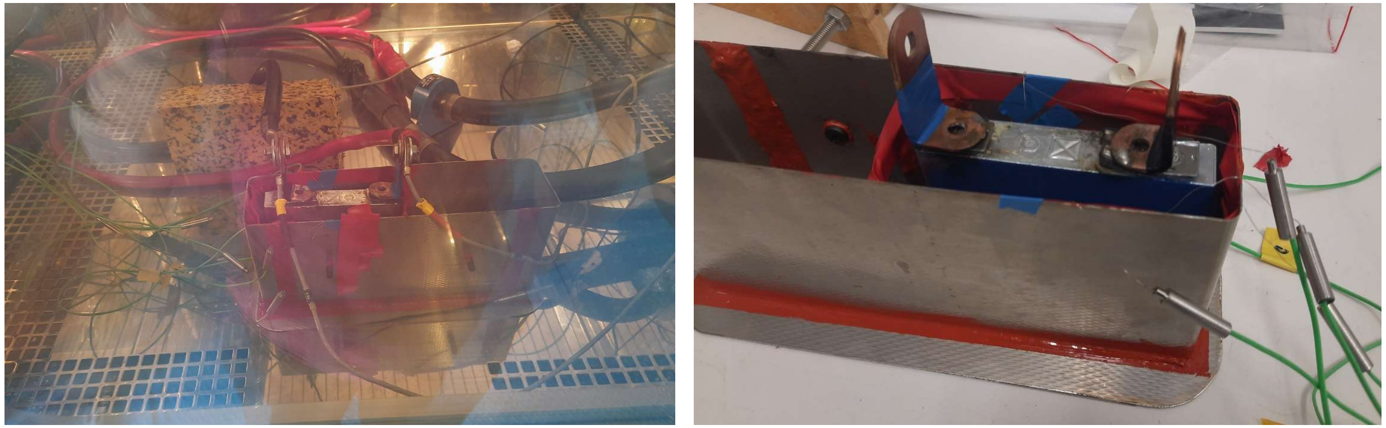
- For passive systems, the best conditions identified in terms of PCM thickness and melting temperature are 10 mm and 40°C, respectively
- For hybrid system the optimal parameters identified are: PCM melting temperature of 40°C, PCM thickness 10 mm, channel depth 2.5 mm, cooling water inlet temperature 30°C.

Main progress done in WP2 Tasks & Deliverables

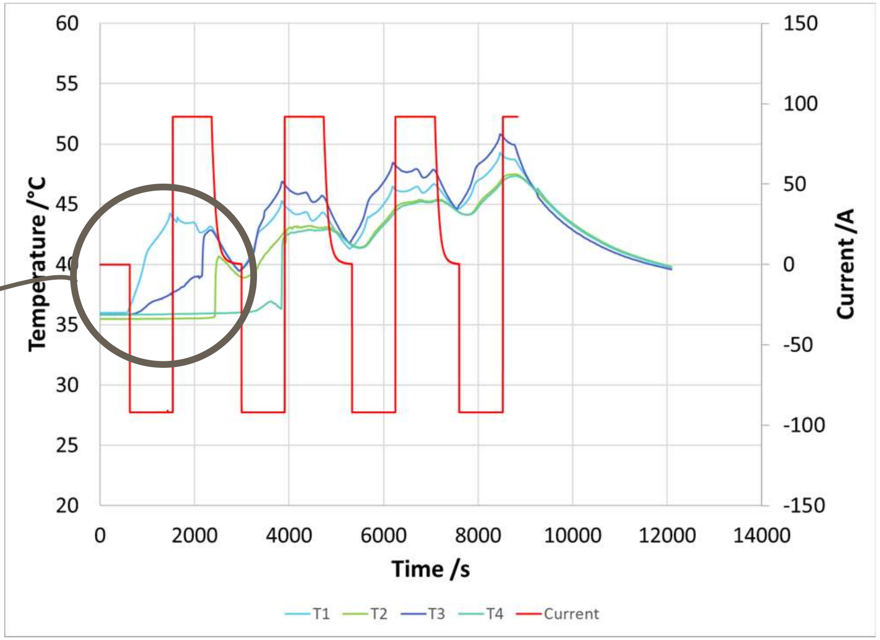
T2.2: Assessment of high-power battery module based on LiB

Thermal management evaluation

On-going experimental activity



- Bio-based PCM for passive management evaluation (T melting: 37°C)
- Preliminary testing: continuous charge/discharge at 4C inside a climatic chamber (T: 25°C)



PHASE CHANGE

Future activities: use cases profiles, different ambient temperatures, hybrid management

THANK YOU FOR YOUR ATTENTION

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