COMSOL CONFERENCE
2017 ROTTERDAM

FH AACHEN
UNIVERSITY OF APPLIED SCIENCES

Implementation of an Active Fluid Cooling Design in a 48 V High-Power Battery Module

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Active Fluid Cooling Design in a High Power Battery Module
Contents

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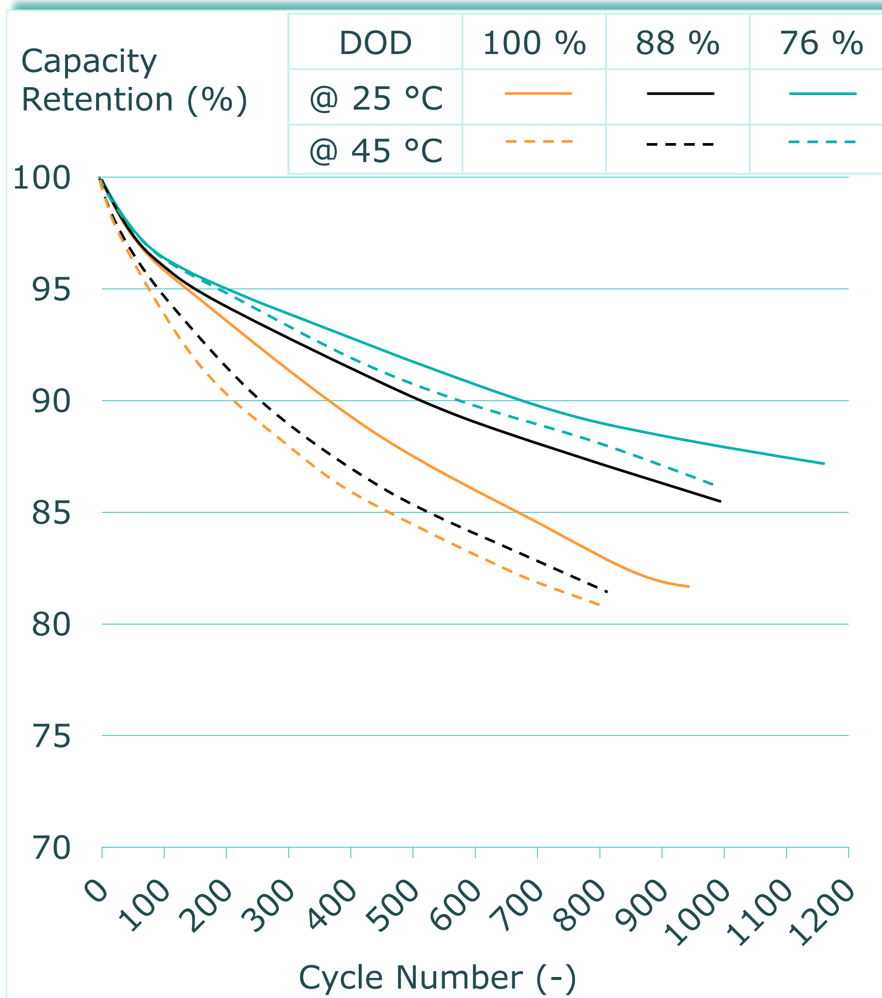
Motivation

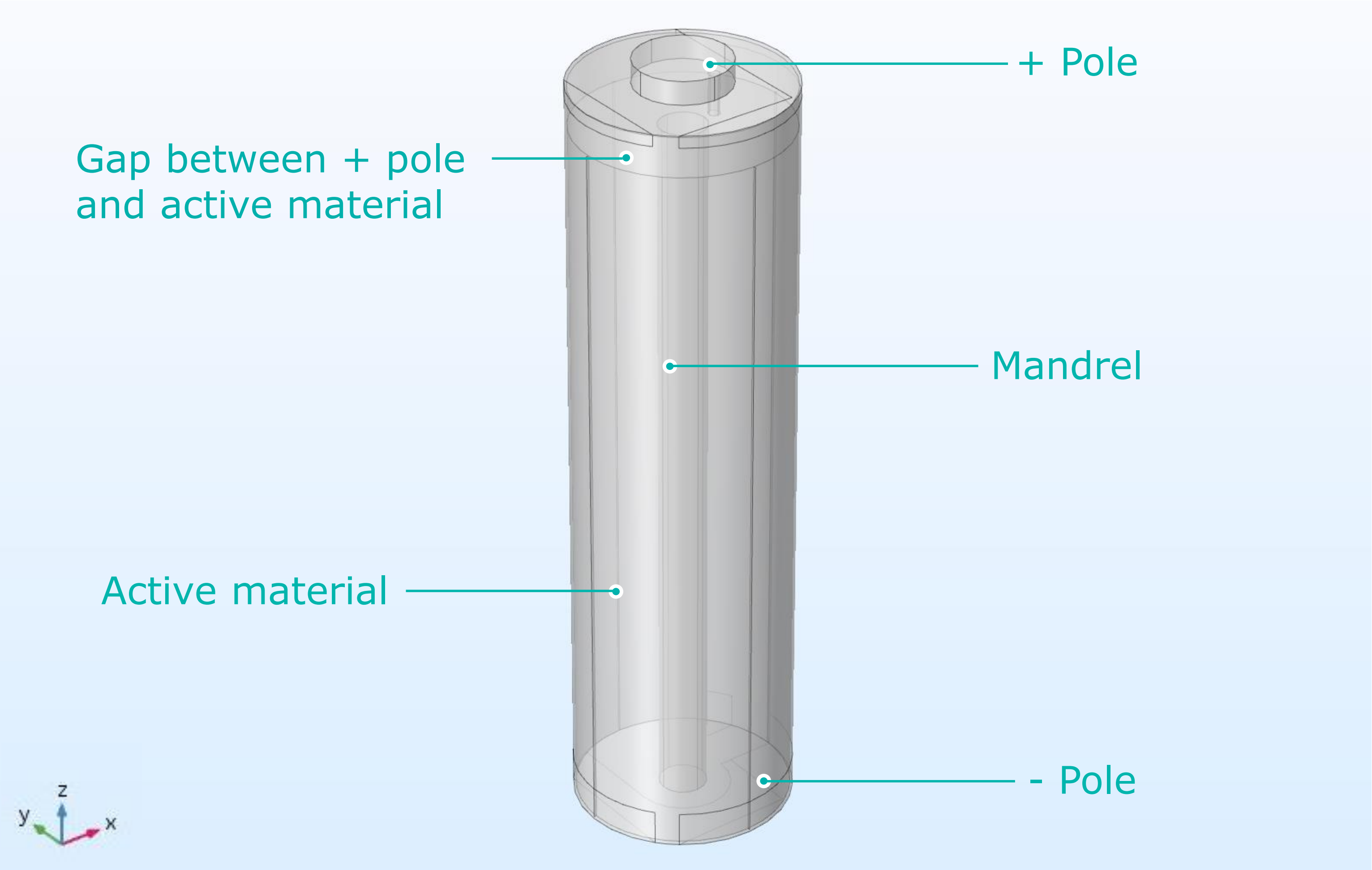
Technical Data
- SAMSUNG INR18650-33G

Cell Chemistry	NCA
Nominal Capacity	11.4 Wh / 3300 mAh
Voltage	2.5 V (2.8 V) / 4.2 V
Standard/Rapid Discharging Current	0.3C / 1C
Pulse Peak Current	10 A 10 s (Rest 30 s)
AC Impedance (1kHz)	27 mΩ
DC Impedance	40 mΩ
Operating Temperature (Charge / Discharge)	-10 ℃ ~ 45 ℃ / -20 ℃ ~ 60 ℃

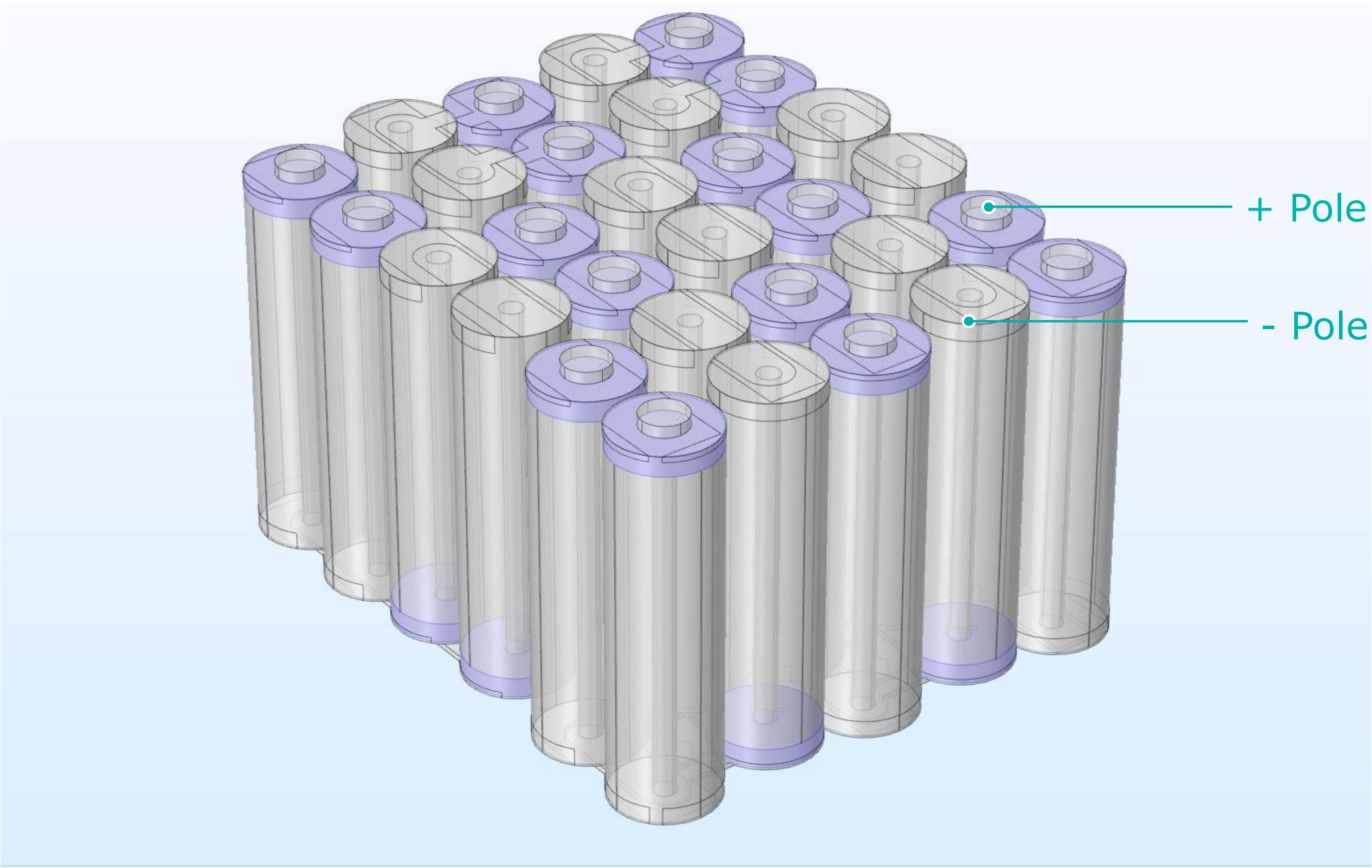


[Source: SAMSUNG SDI, Cell Development Q.A "Cylindrical 18650 (11.4Wh) EV Technical Report", January 2015.]

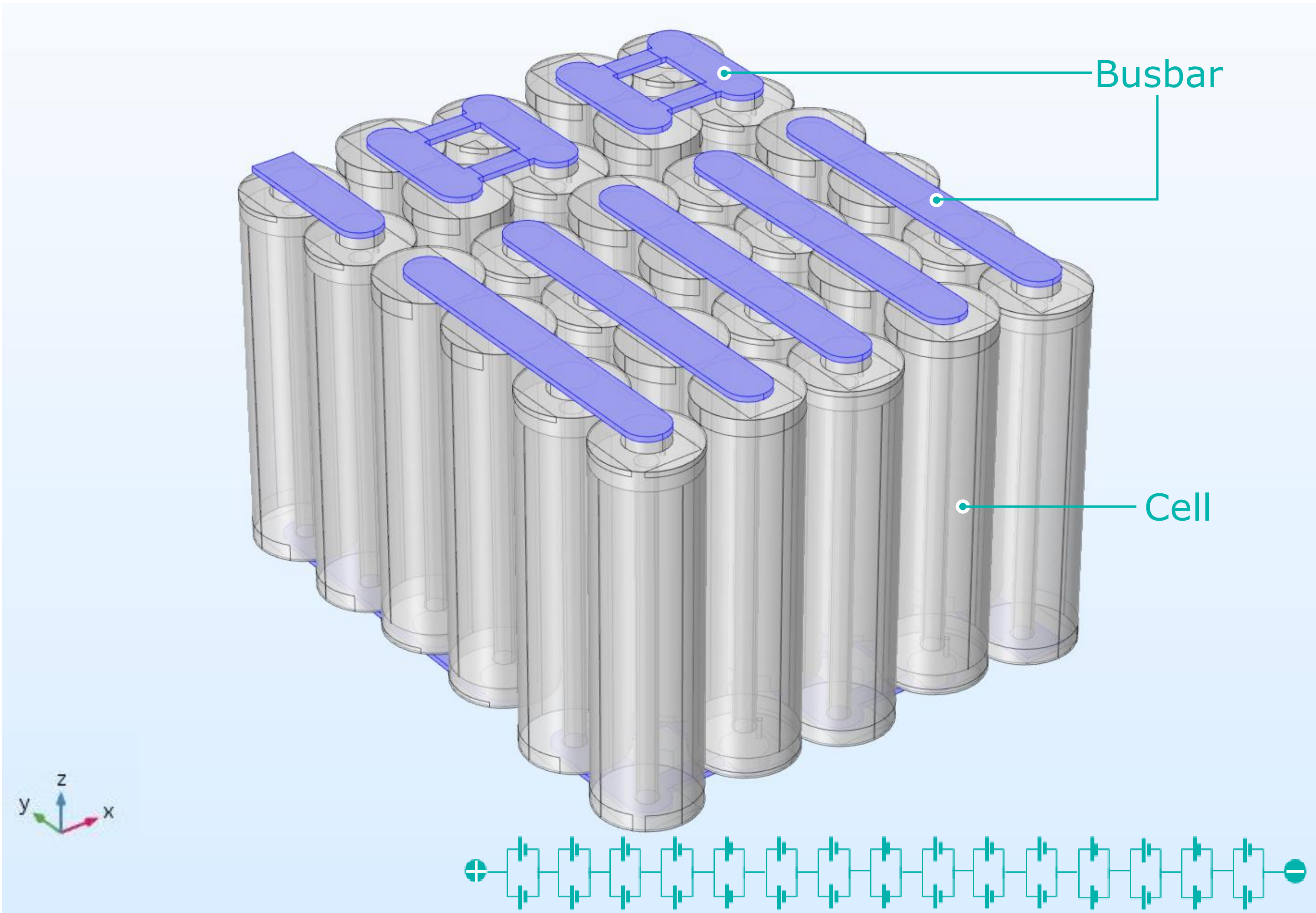
Ground Model
Partially Lumped Single Cell Model



Ground Model
Battery Module



Ground Model
Battery Module



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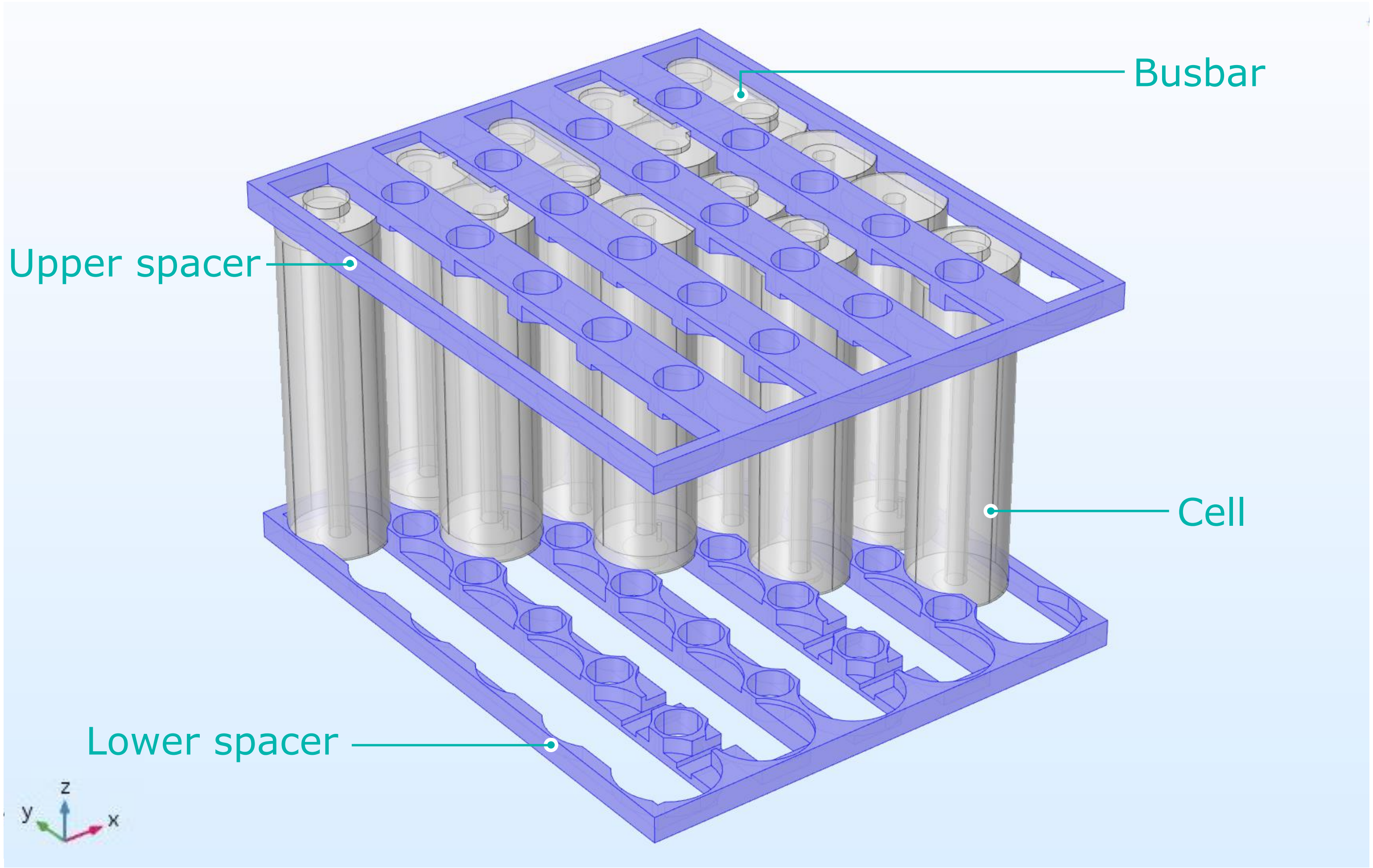
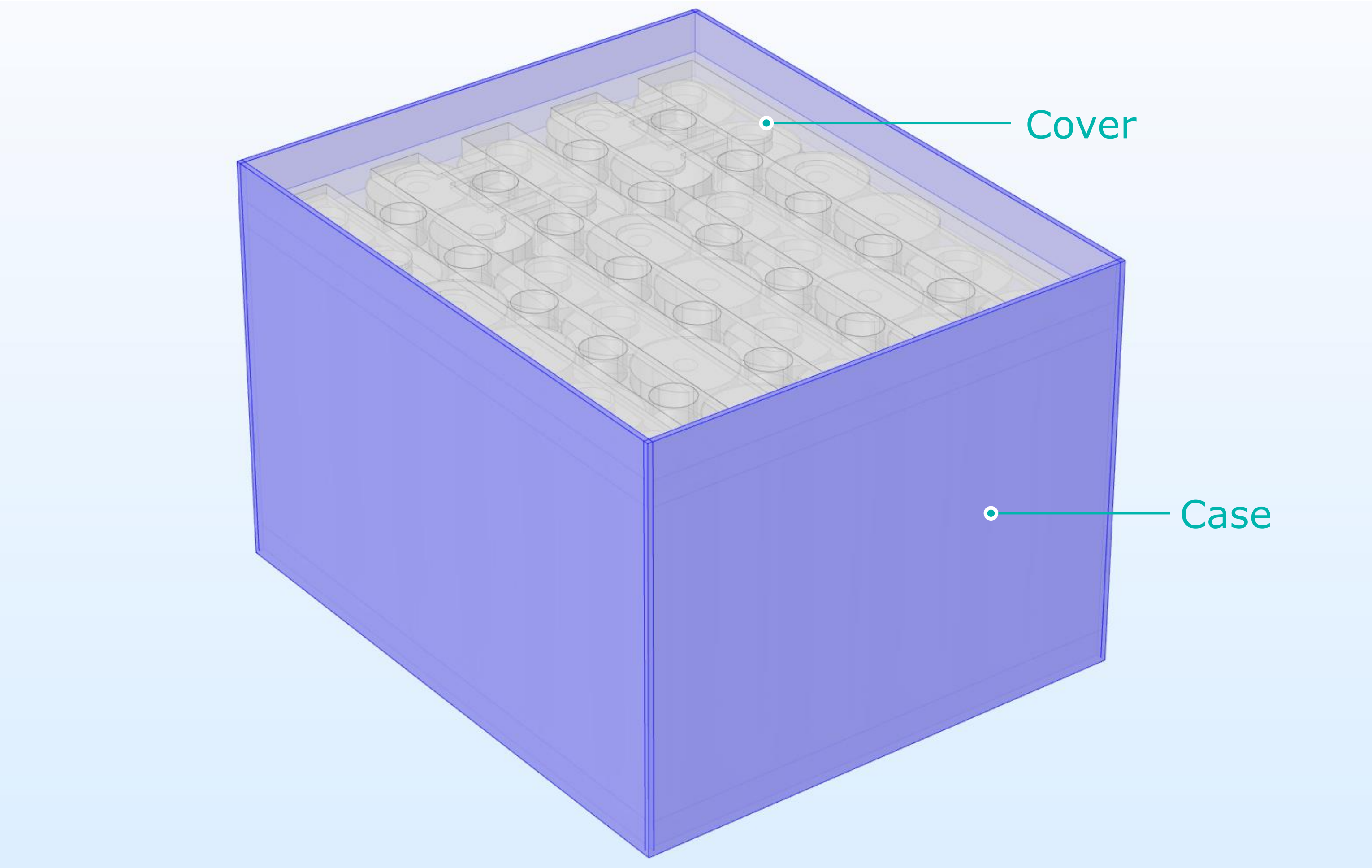
Ground Model
Battery Module

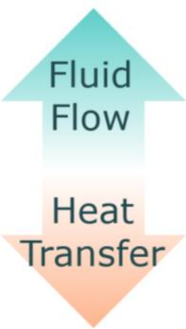


Ground Model
Battery Module



Thermal Analysis
Ground Model

- Software COMSOL Multiphysics ®
- Principle: Stationary FEM
- Scope: 3D, transient model
- Coupling of Non-Isothermal Flow:



Navier Stokes Equation:

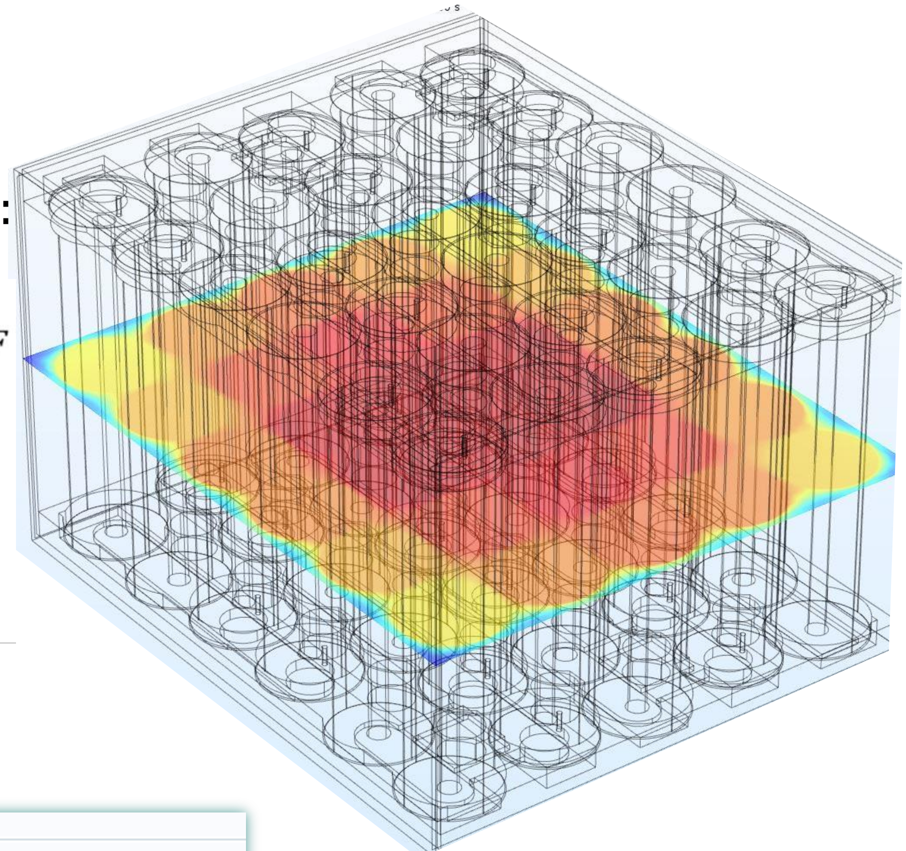
$$\rho(\boldsymbol{T})(\boldsymbol{u}\cdot\nabla\boldsymbol{u}) = -\nabla p + \mu(\boldsymbol{T})\Delta\boldsymbol{u} + F$$

Temperature Field

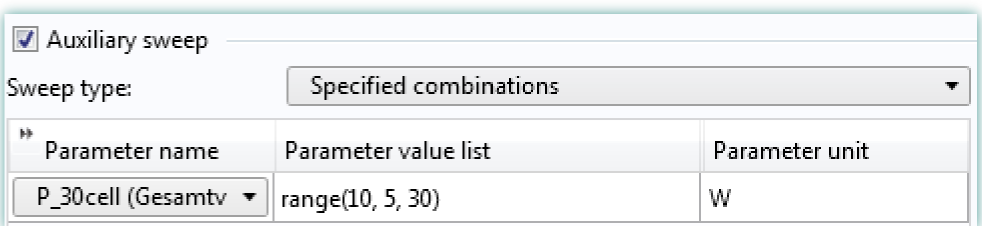
Heat Transport Equation:

$$\rho C_p\boldsymbol{u}\cdot\nabla\boldsymbol{T} + \nabla\cdot(-k\nabla\boldsymbol{T}) = Q$$

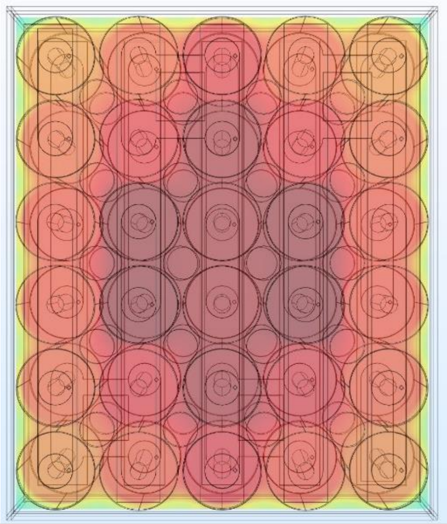
Velocity Field

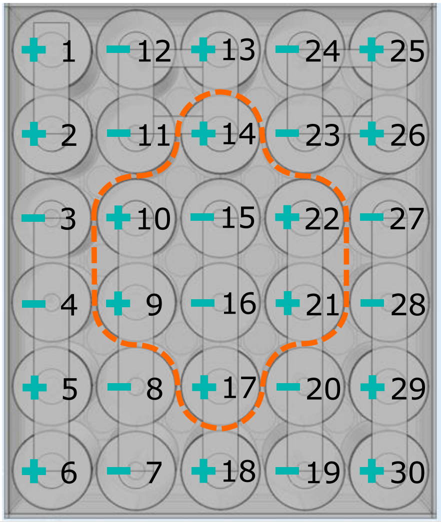


- Parametric sweep for module heat generation rate:



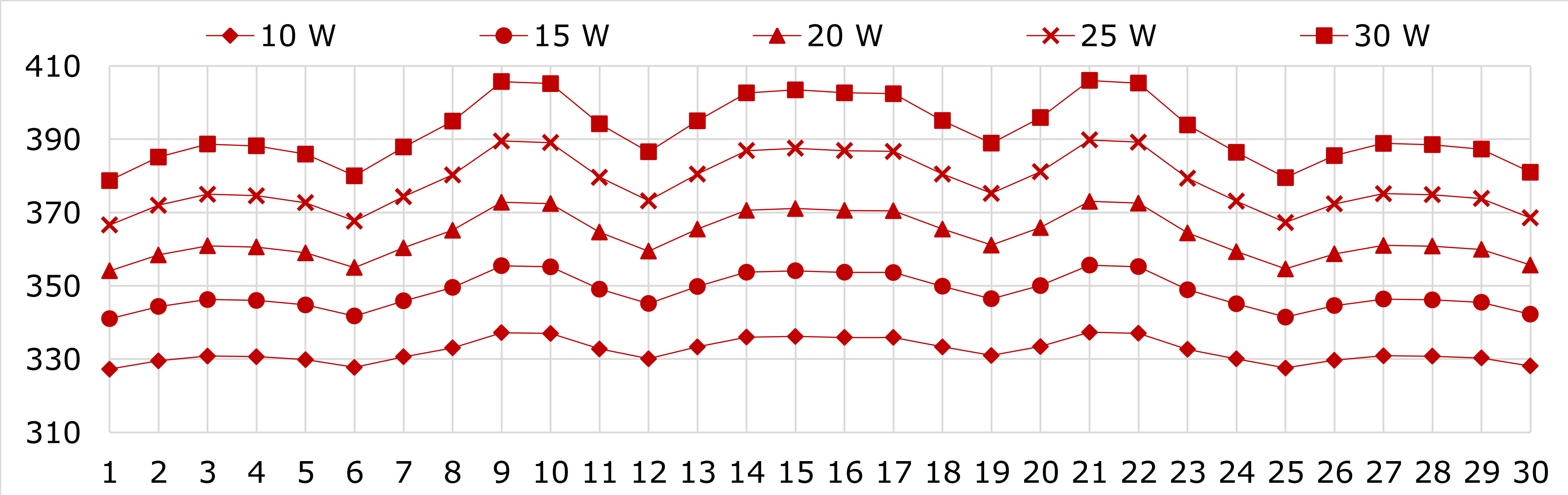
Thermal Analysis
Ground Model





Objective 1 $T_{max} \downarrow$

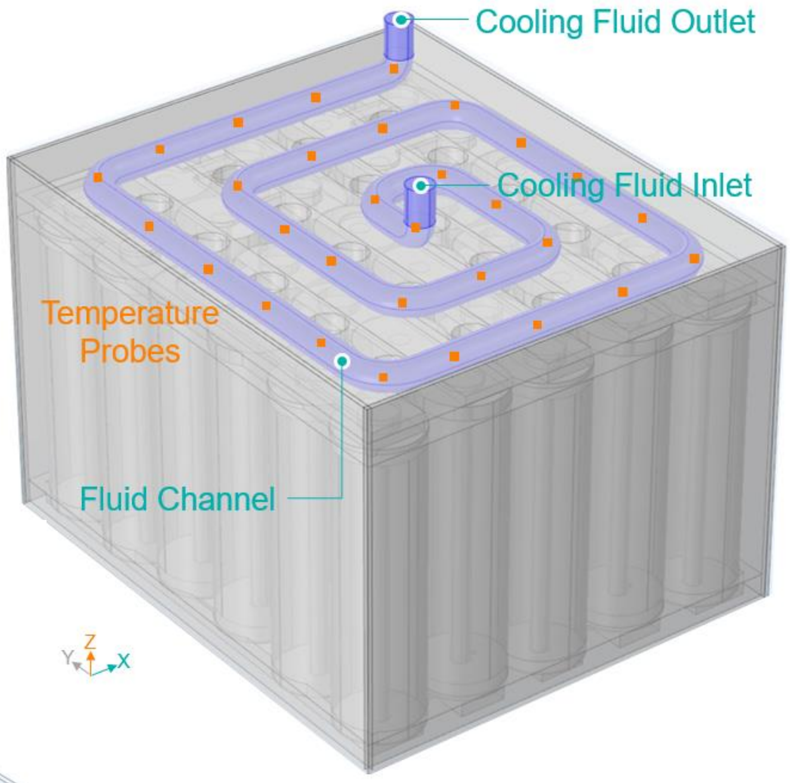
Objective 2 $\downarrow \Delta T$

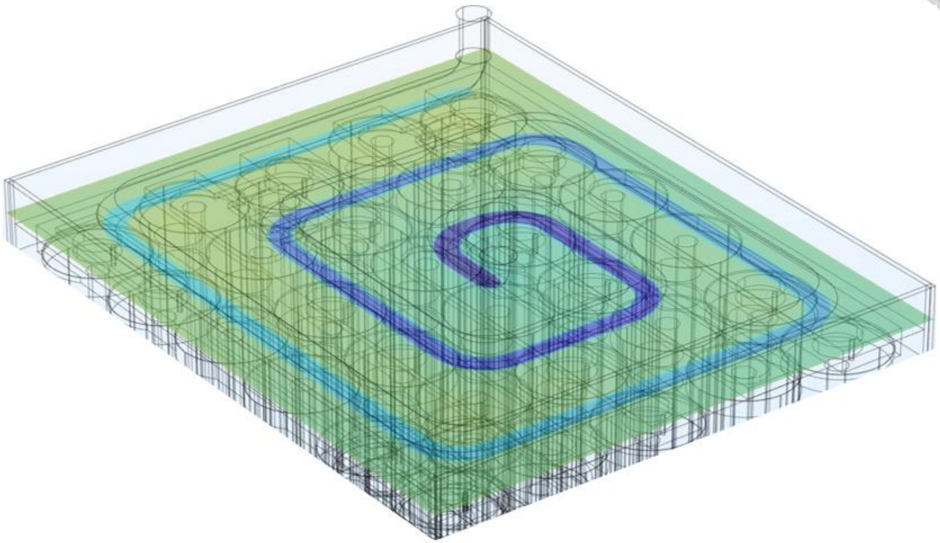


Thermal Analysis

GM & Active Fluid Cooling (AFC)

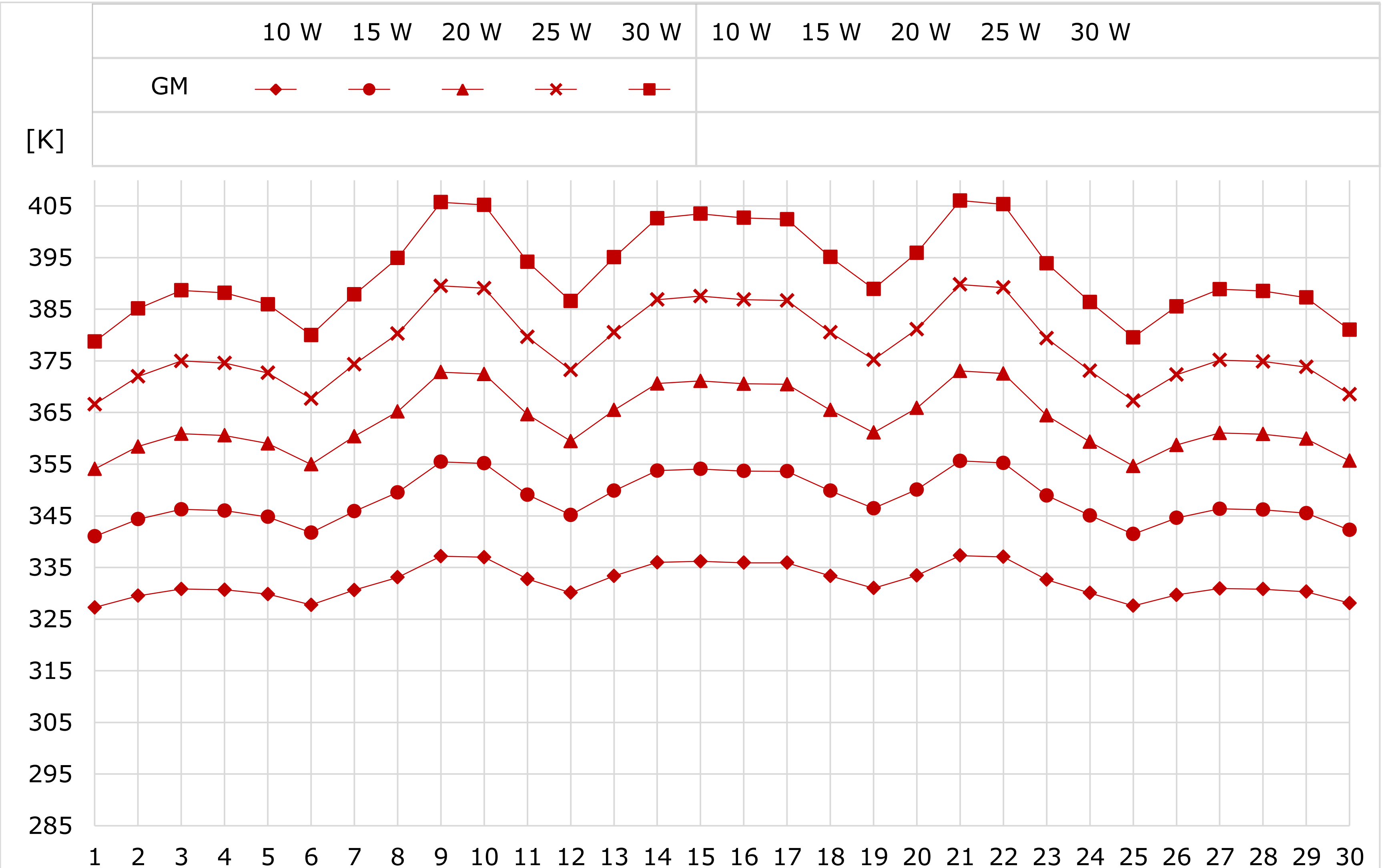
- Fluid channel is embedded in Al cover
- Inlet at module center
- Outlet at module edge
- Temperature probes along the fluid channel to visualize the heating of cooling Water





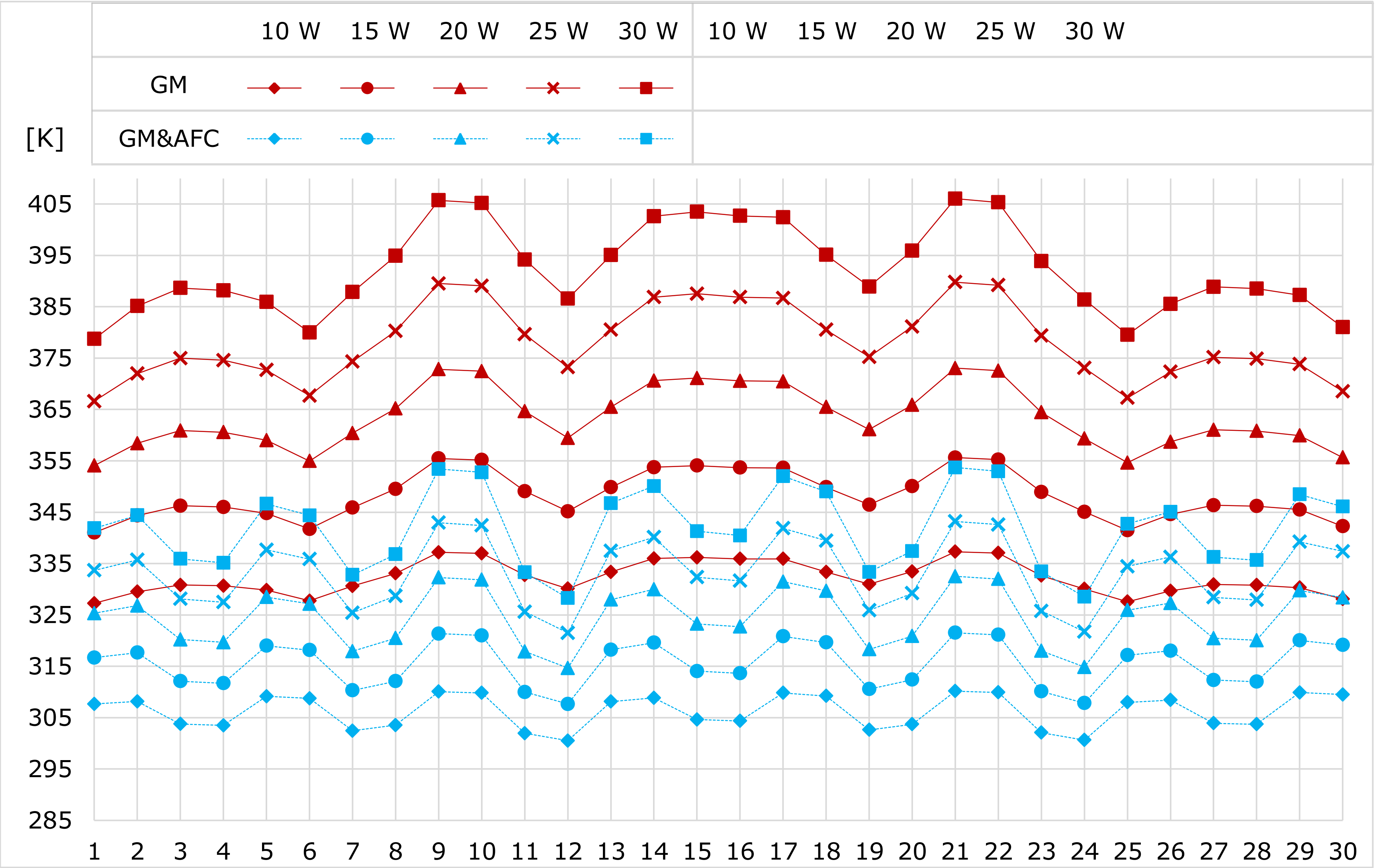
Thermal Analysis

GM & Active Fluid Cooling (AFC)



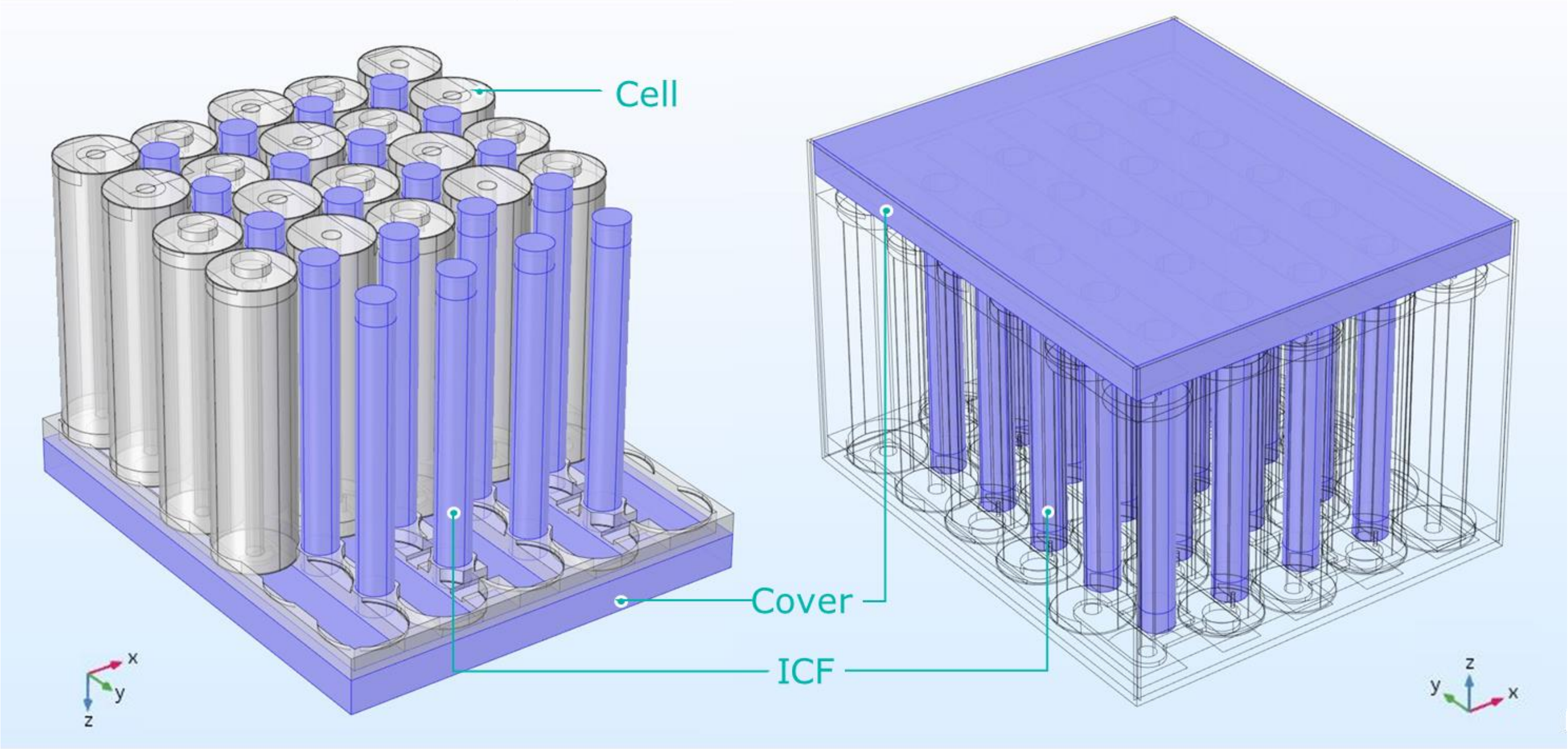
Thermal Analysis

GM & Active Fluid Cooling (AFC)



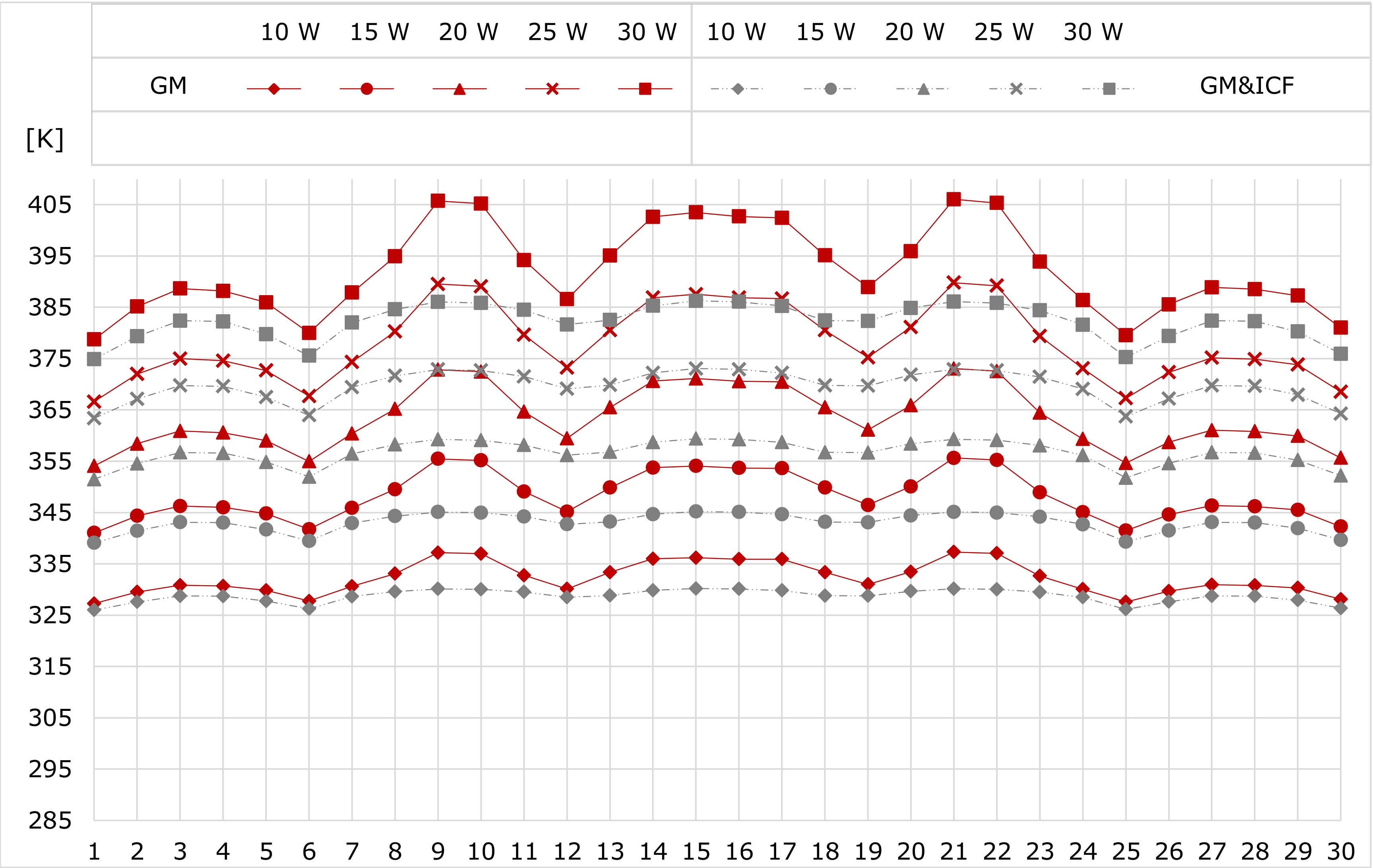
Thermal Analysis

GM & Internal Cooling Fin (ICF)



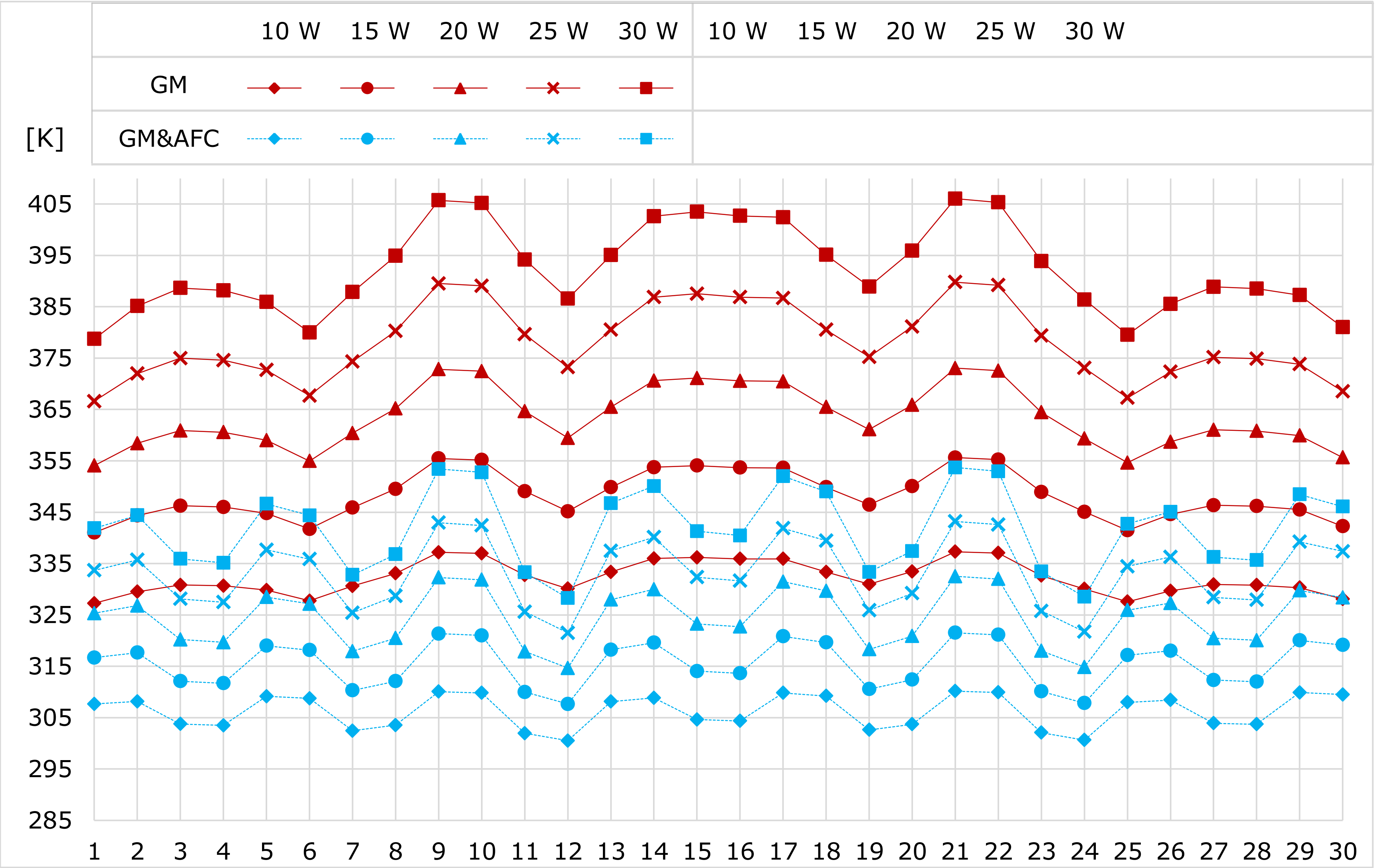
Thermal Analysis

GM & Internal Cooling Fin (ICF)



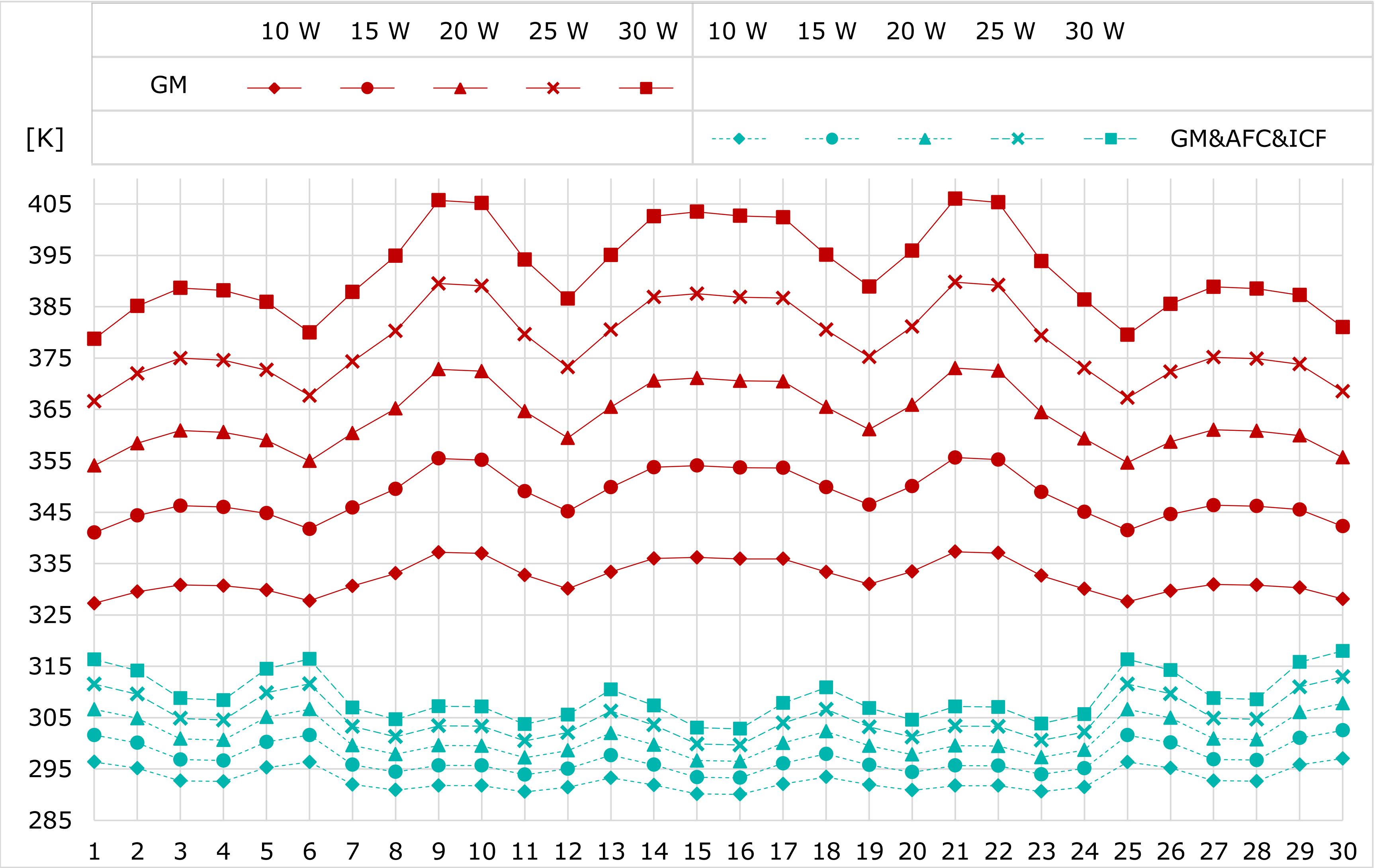
Thermal Analysis

GM & Active Fluid Cooling (AFC)



Thermal Analysis

GM & AFC & ICF



Active Fluid Cooling Design in a High Power Battery Module

Summary

- Simulative thermal analysis is a helpful step before conducting actual tests
- Temperature distribution in GM (no cooling concept is involved) is uneven
  → differences in cell cycle life within the same battery module
  → a shortened cycle life of the entire module
- By involving detailed measurement data of employed cells, both the complexity and the accuracy of the simulation models can be increased
- Effects of passive cooling concepts are analyzed

	ICF	AFC
Temperature uniformity	++	0
Reduction of cell temperatures	+	++

- Combined systems with different passive cooling principles shall be involved for large and high power battery module

非常感谢!

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