

Heat Generation Modeling of a Lithium Battery: from the Cell, to the Pack on COMSOL Multiphysics

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Thursday, October 15th 2015

In collaboration with

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Summary

- Introduction
- Background
- Goal
- Parameters determination
- Physical and computational model
- Results
- Conclusion

Introduction

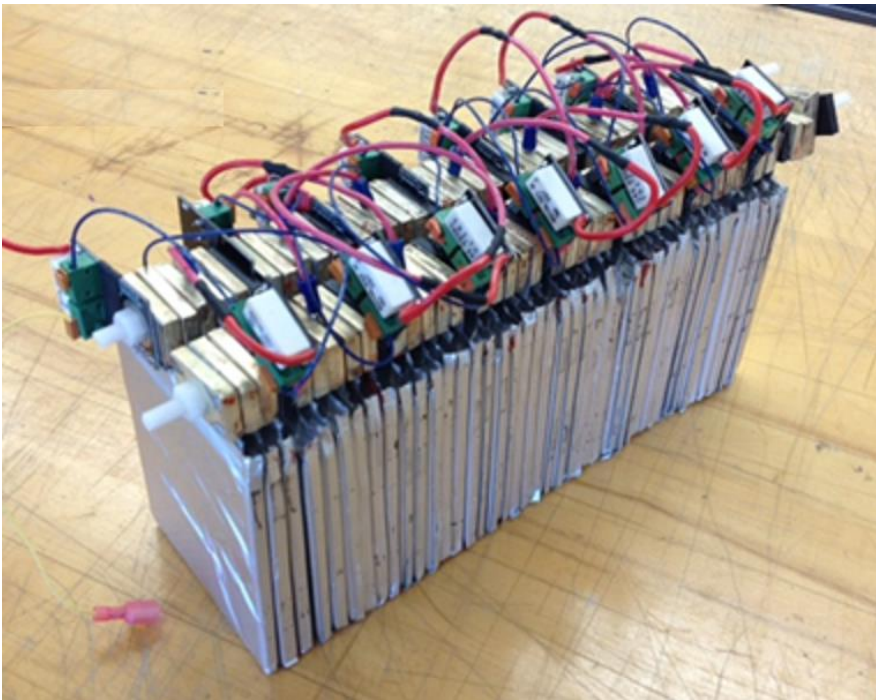
- Lithium ion battery, energetic density
- Performance, life, and temperature



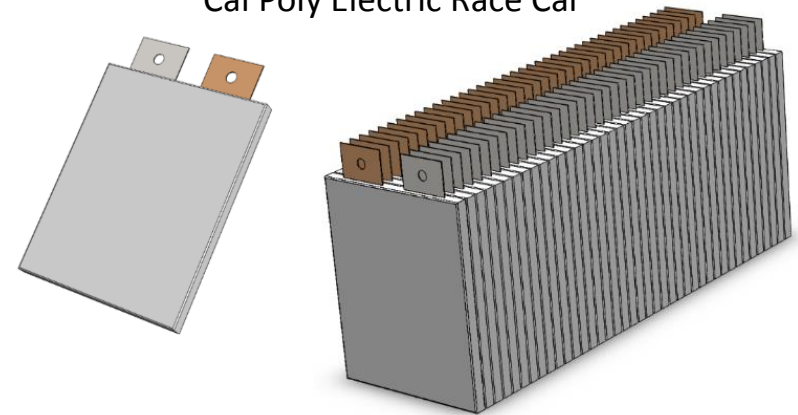
Electric car : Automobile-propre.com

E-Fan : sti.tice.ac-orleans-tours.fr

- Comsol Multiphysics, Fuel Cell module



Cal Poly Electric Race Car

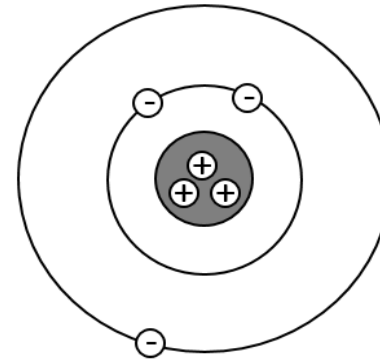


Cal Poly electric race car battery pack

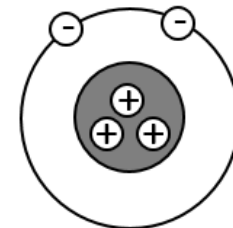
- Lithium atom properties, and aspect



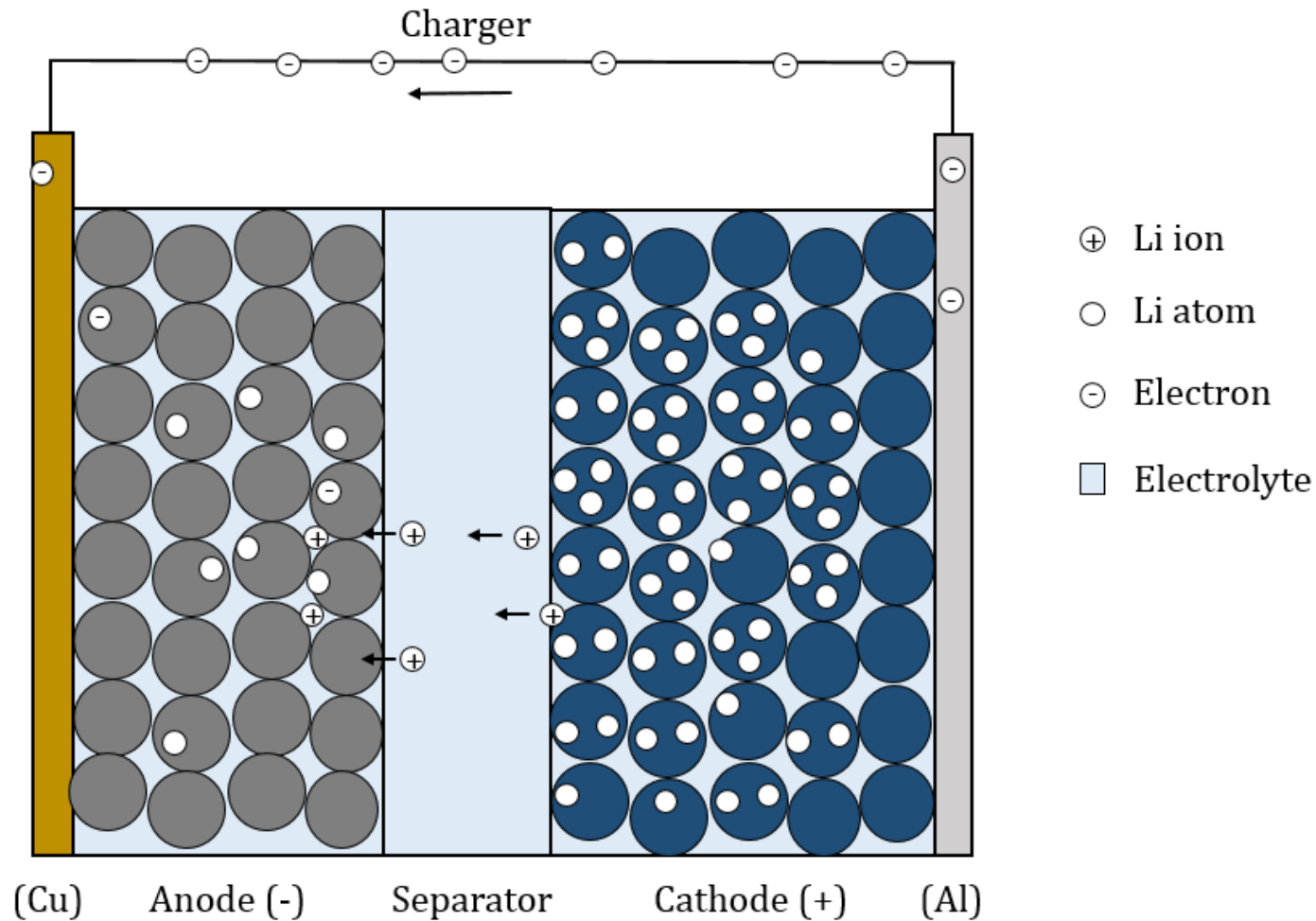
Lithium pure : news.softpedia.com



Atom Li



Ion Li⁺

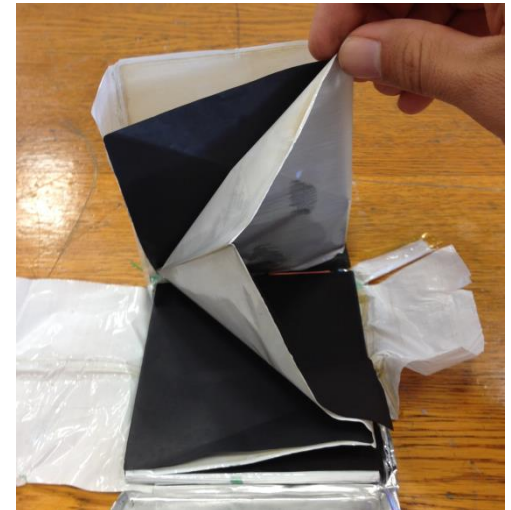


Lithium batterie operation (charge)

Background



Cell 33 opened



Goals

- Simulation 1 : Figure out the heat generation of the battery cell during the discharge.

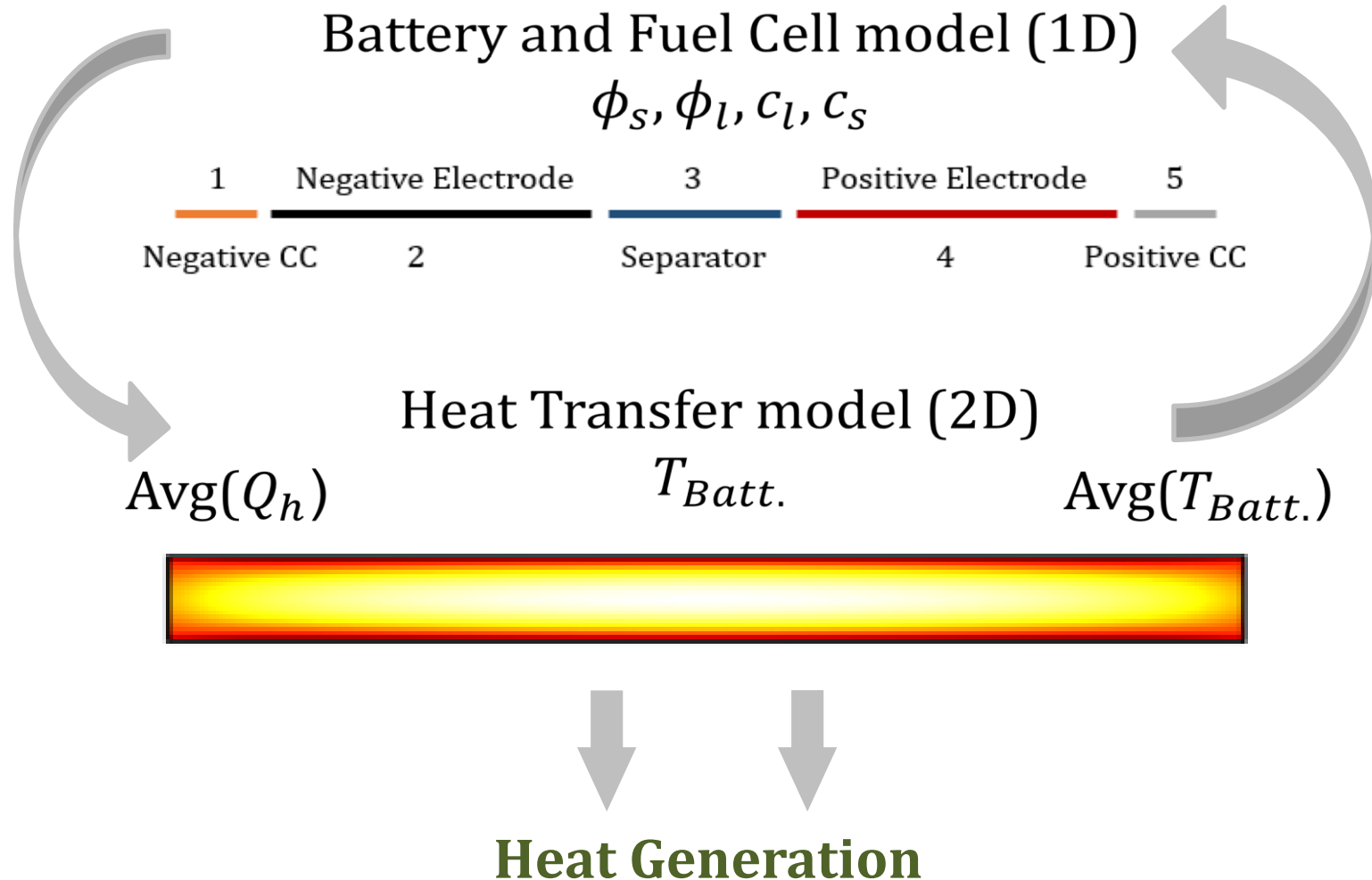


Comsol Modules : Battery and Fuel Cell + Heat Transfer

- Simulation 2 : Figure out the temperature elevation of the Battery pack.

Comsol Module : Heat Transfer

Simulation 1: Heat Generation

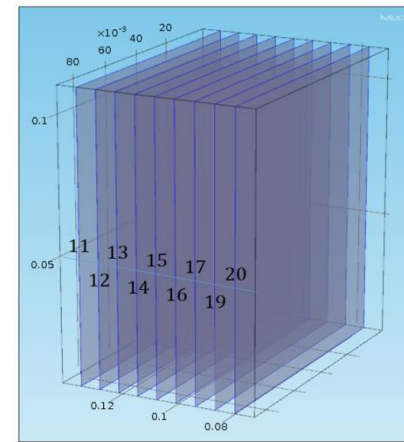
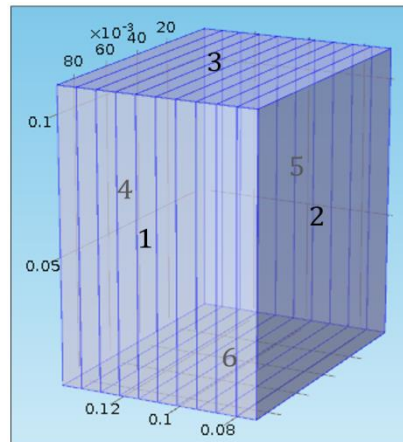
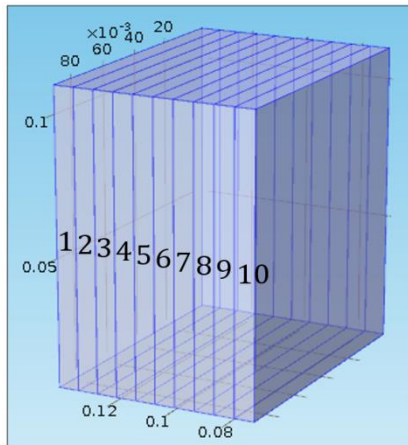


Simulation 2 : Temperature Elevation

Heat Generation

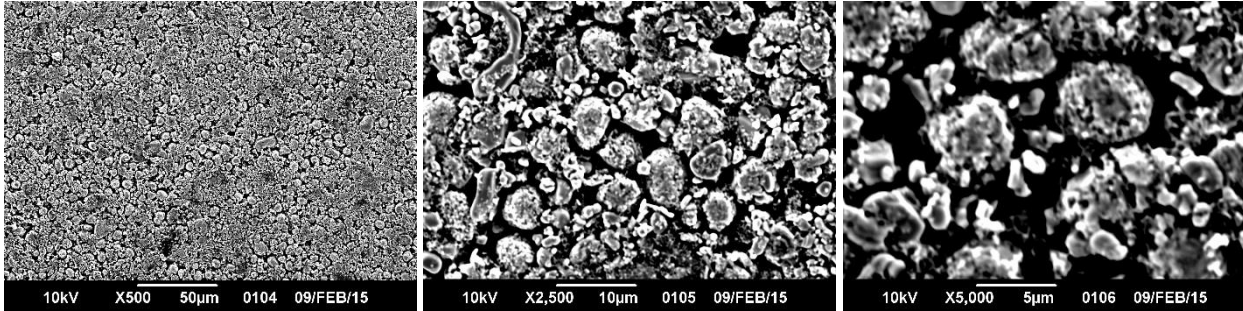


Heat Transfer model (3D)

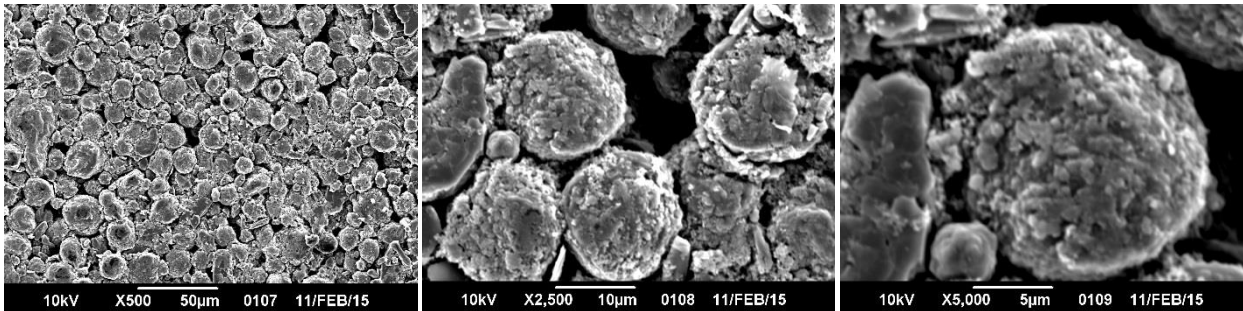


Temperature Elevation

Cal Poly Electric Car Battery Cell



Positive Electrode (Li_yCoO_2)



Negative Electrode (LiC_6)



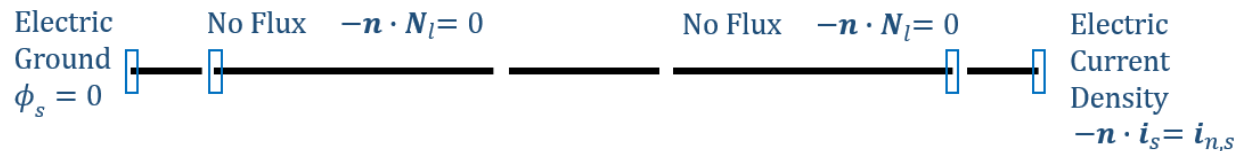
Scanning electrons microscope

Physical and computational model

➤ Simulation 1



Boundary Conditions



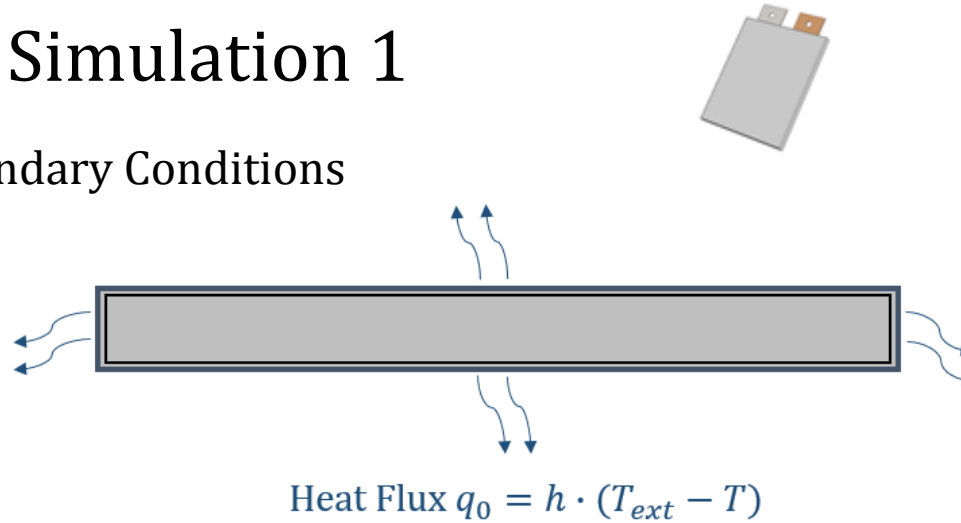
Initial Conditions



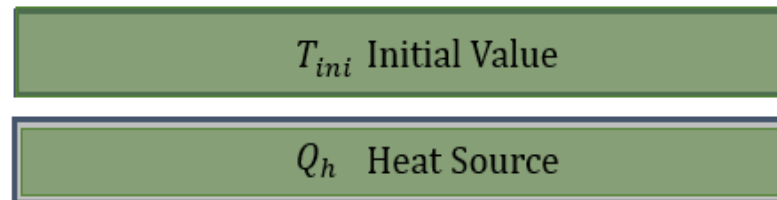
Physical and computational model

➤ Simulation 1

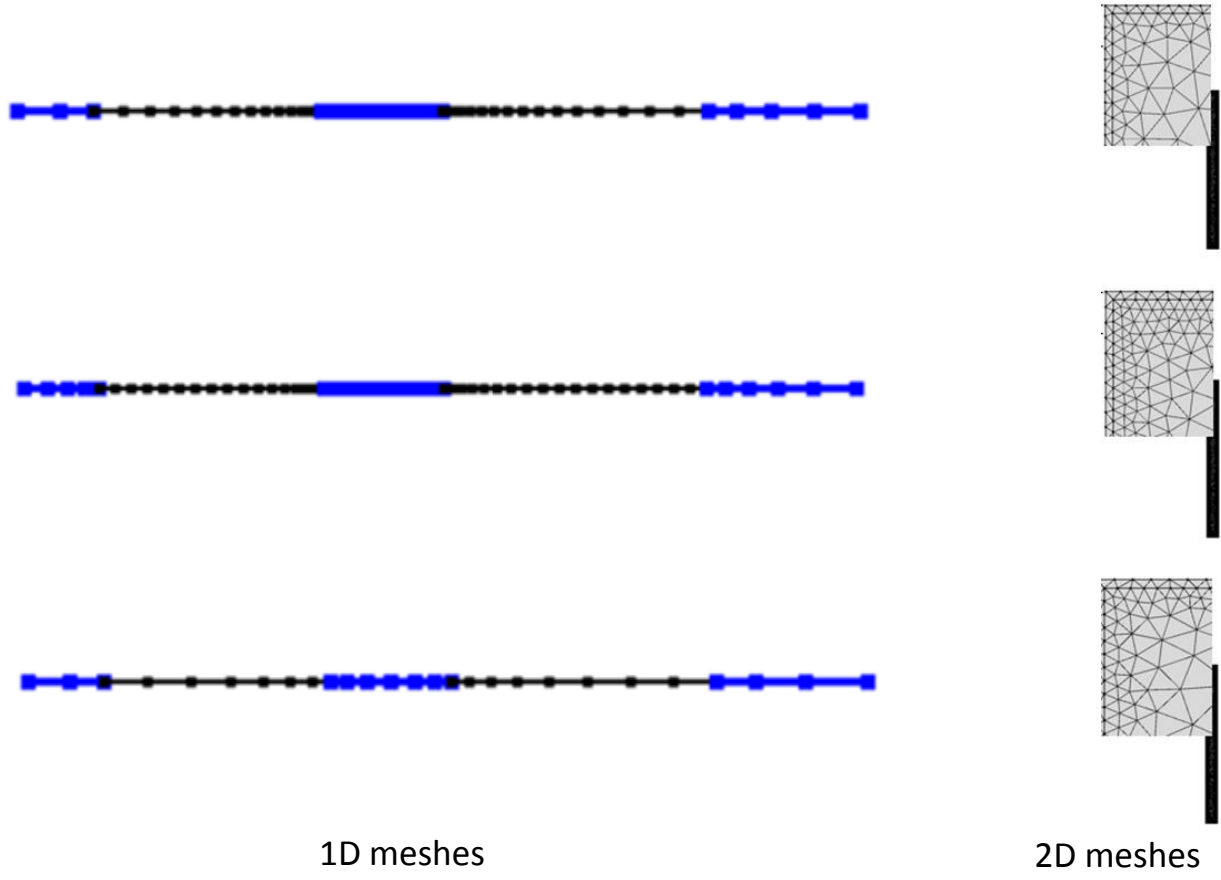
Boundary Conditions



Initial Conditions



Physical and computational model

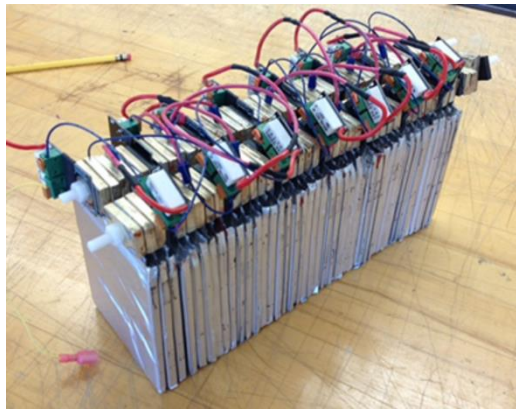


1D meshes

2D meshes

Physical and computational model

➤ Simulation 2

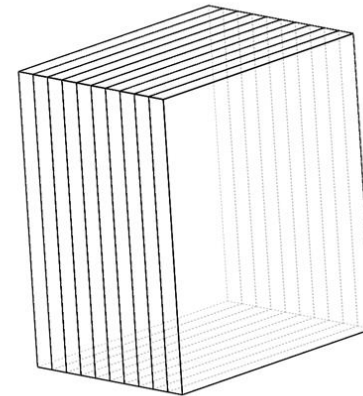


Real pack



One element

Example Battery Pack (10x)



Model Pack 10x

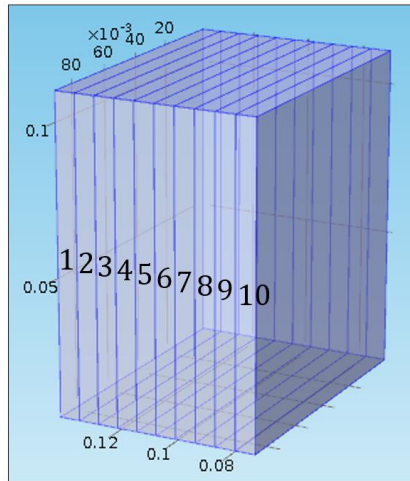
Physical and computational model

Heat generation : Battery 3, time : 720 [sec], Initial temperature 25[degC]

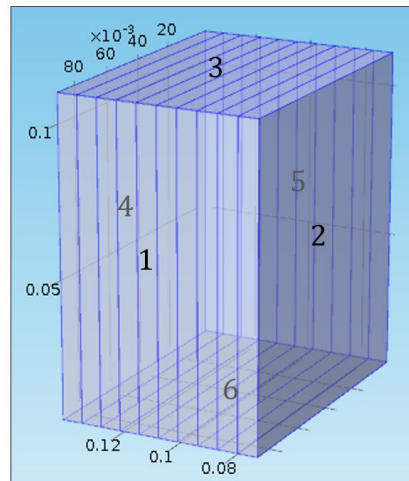
Heat transfert in a solid

Boundary conditions

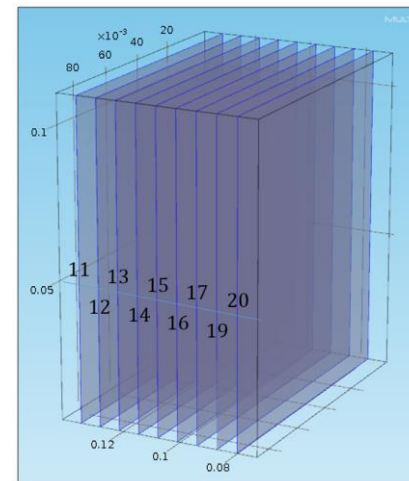
Thin thermally resistive layers



10 bodies of the pack

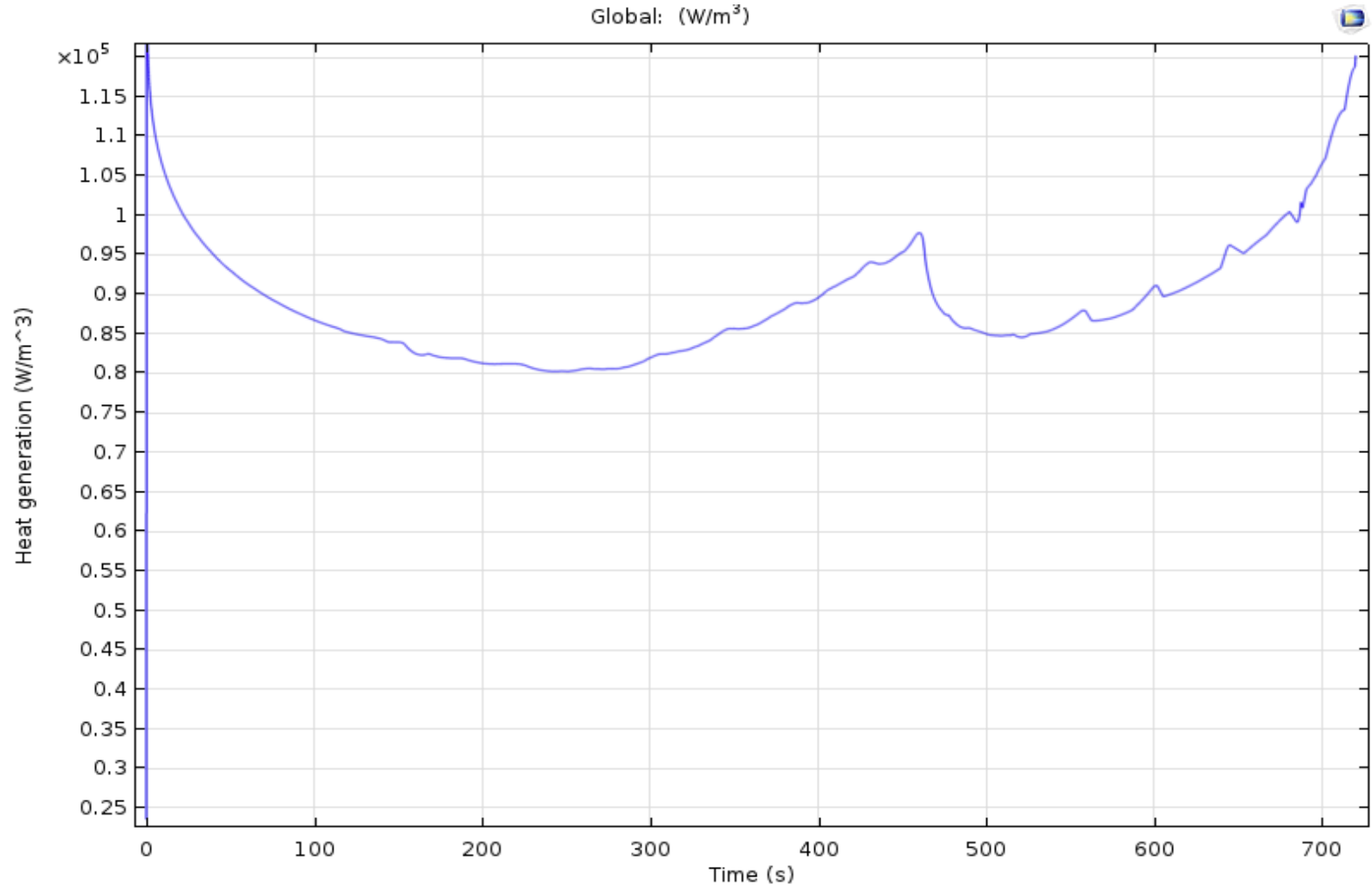


6 external surfaces



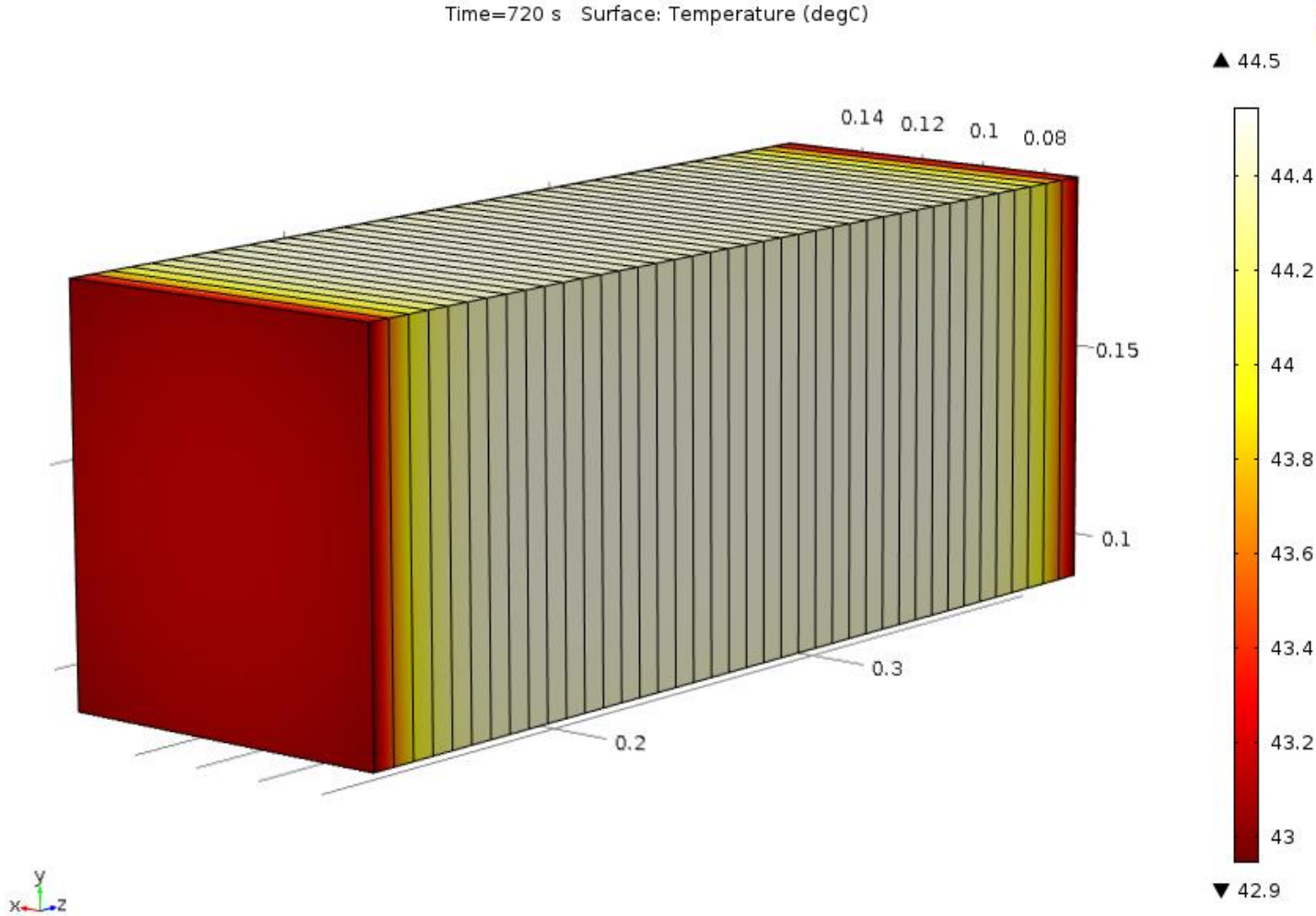
Boundaries created by the enclosure

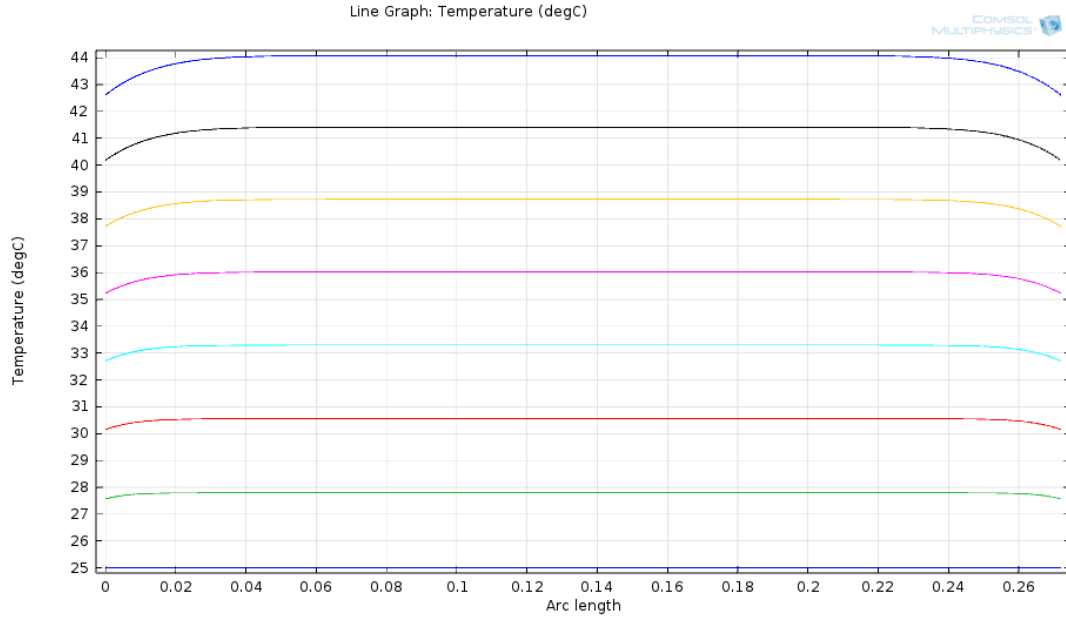
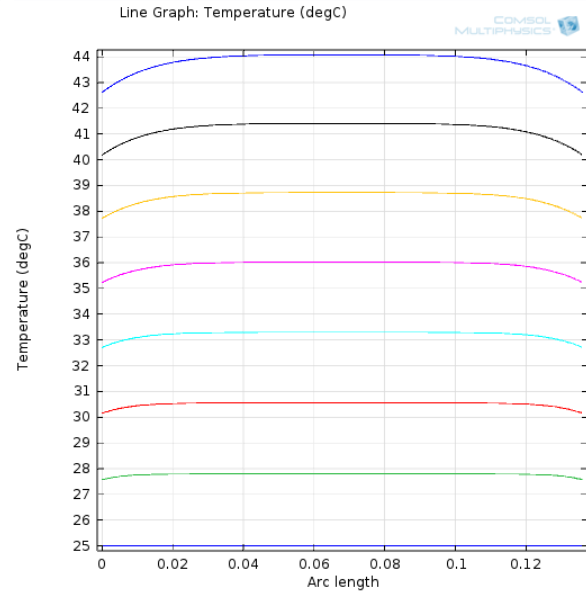
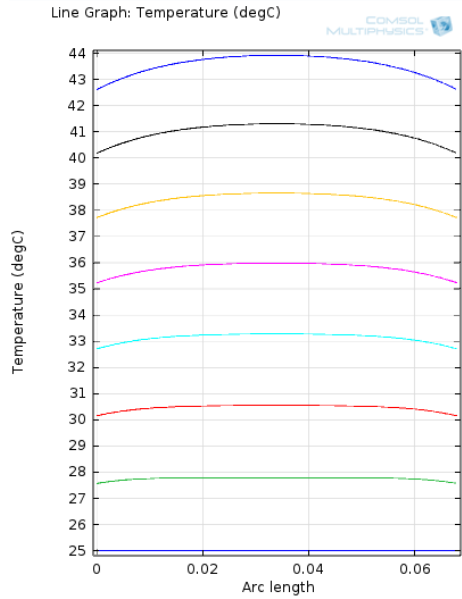
Results : Simulation 1



Results ; Simulation 2

Time=720 s Surface: Temperature (degC)





Pack effect : 5.6 [degC] 9.1 [%] error

- **Improvement of the Comsol model**

Parameters : Electrical conductivities (electrons), diffusivities (ions)

- **Improvement of the experiments**

Measure the temperature elevation accurately on the packs and the cells

Thanks for your attention