



## ALTAIR BATTERY DESIGNER

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Marian Bulla - Material Technical Specialist  
Patrick Lombard - Lead application specialist



# Background

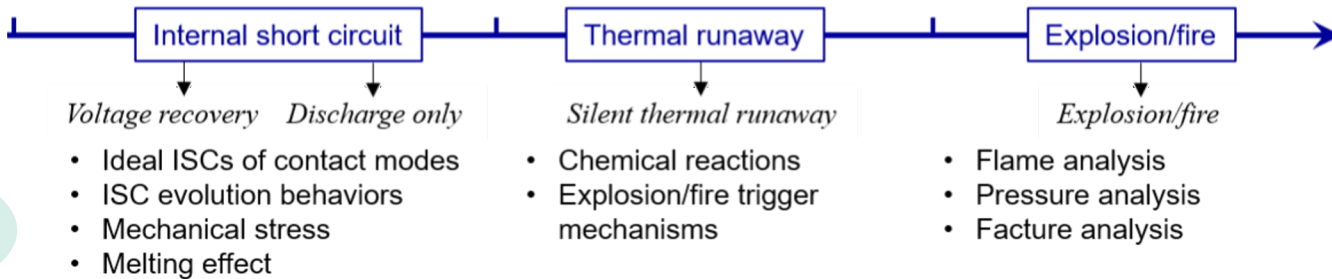
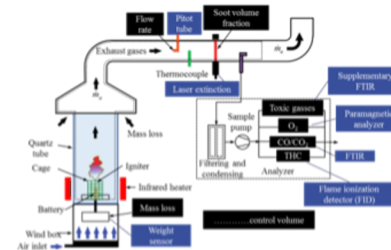
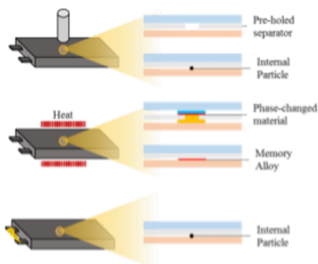
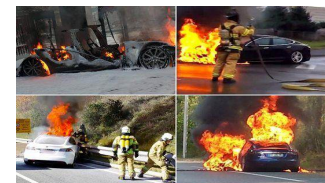
- Mechanical abusive loading

- Li plating

- Li dendrite

- Particle crack

- Separator failure



# ALTAIR STATUS

# Altair Radioss™ - Battery Modeling Under Mechanical Loads

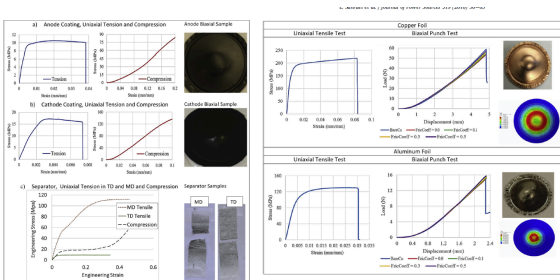


Fig. 4. Hardening properties of the anode and cathode coatings as well as the separator in tension and compression.

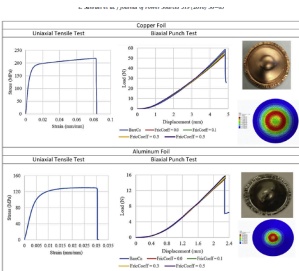
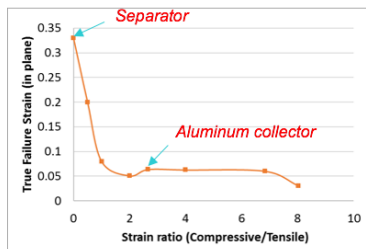
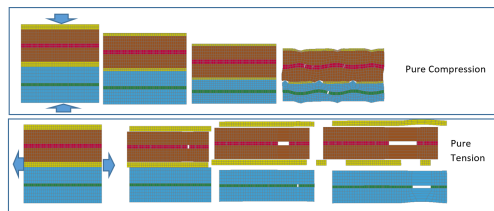


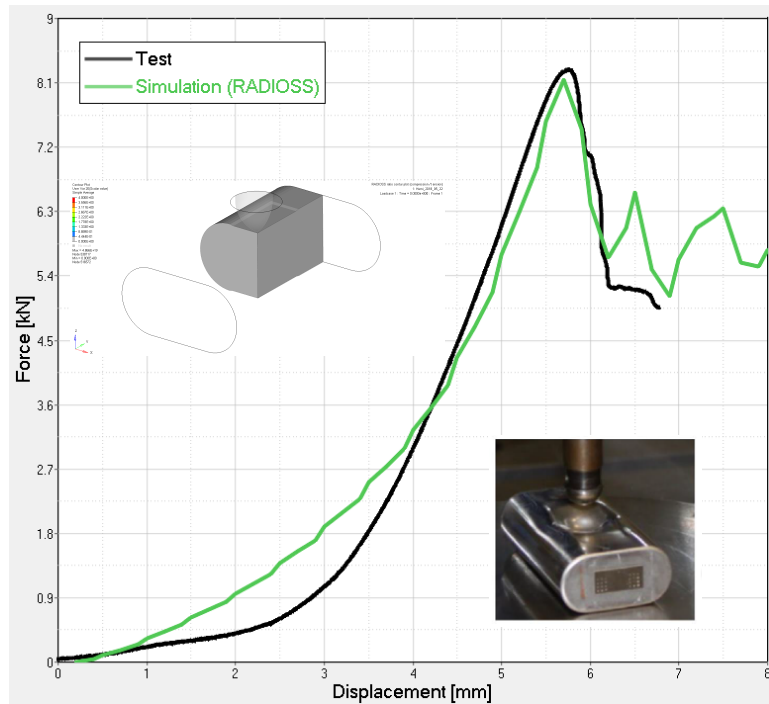
Fig. 5. Hardening properties of copper and aluminum current collectors calibrated from uniaxial and biaxial tests.

Homogenized material used with continuum mesh inside the cells



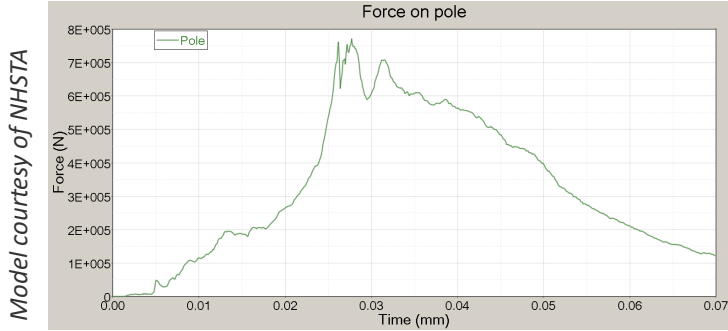
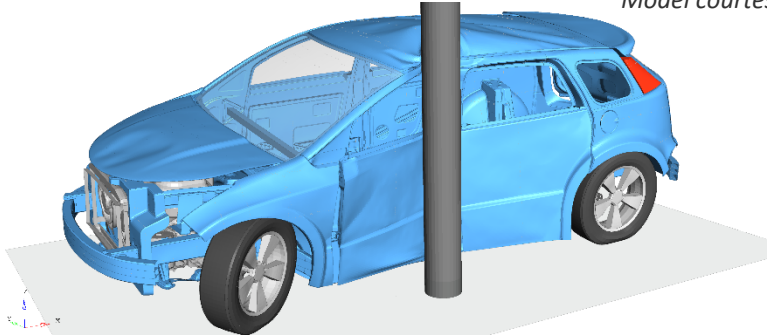
Failure model Elham Sahraei research (MIT Battery Consortium, Temple University) /FAIL/Sahraei into Radioss

Very good fit of the test results

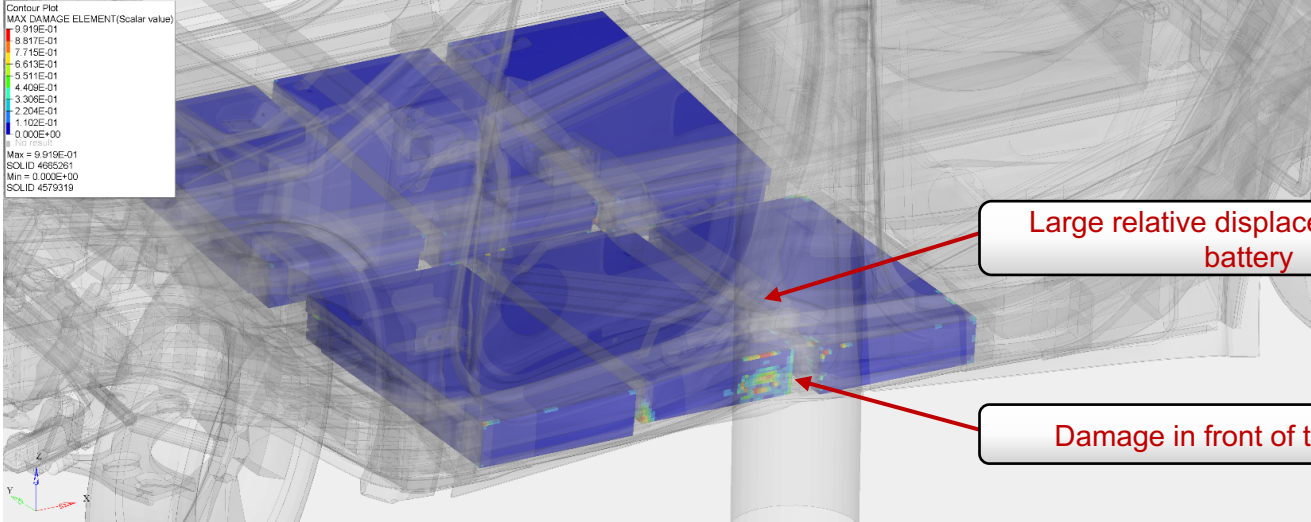


# Full Car Crash Model Application

Model courtesy of NHSTA



Contour Plot  
MAX DAMAGE ELEMENT(Scalar value)  
9.919E-01  
8.817E-01  
7.715E-01  
6.613E-01  
5.511E-01  
4.408E-01  
3.306E-01  
2.204E-01  
1.102E-01  
0.000E+00  
0.000E+00  
Max = 9.919E-01  
SOLID 4685261  
Min = 0.000E+00  
SOLID 4579319



Large relative displacement of the battery

Damage in front of the B-pillar

# MECHANICAL AND ELECTRO-THERMAL BATTERY CELL SIMULATIONS VALIDATION OF THE METHOD



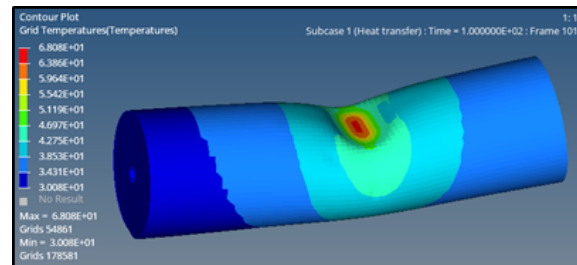
## Background

- **Collaboration**

- Altair Engineering
- Professor Jun Xu - *Vehicle Energy & Safety Laboratory (VESL), NC Motorsports and Automotive Research Center, UNCC*

- **Objective:** Validate a method to calculate the risks of thermal runaway

The validation is based on comparing numerical results and experimental data





# Cell experimental setup and simulation models

NCR 18650B battery, 30% SOC

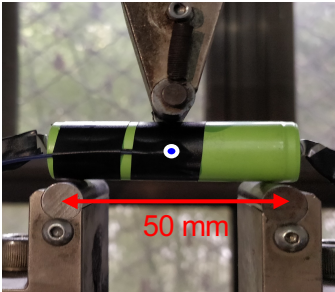
Compression



Indentation

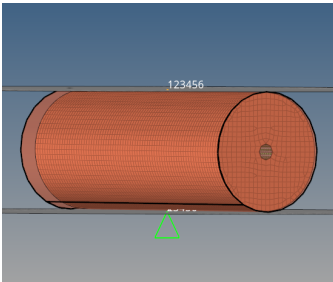


Three-point bending

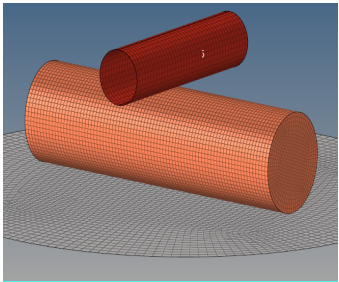


- Thermocouples are usually set at the center of the battery;
- The force, voltage and temperature are measured at the same time;
- Loading rate: 5 mm/min.

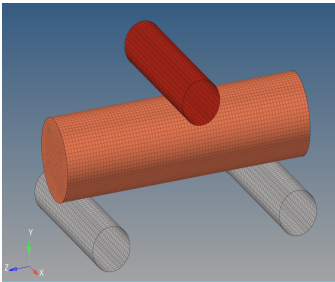
• Temperature Points



CPU Time : 451 s.



509 s



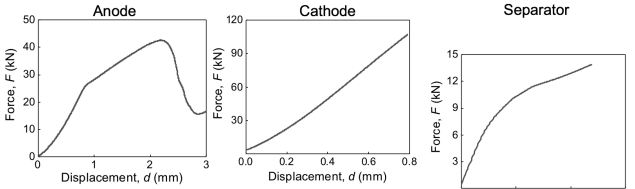
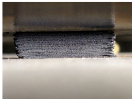
3273 s

- Number of elements: 31.425
- Element time step:  $4.27 \cdot 10^{-7}$  s
- Nodal time step :  $12.00 \cdot 10^{-7}$  s

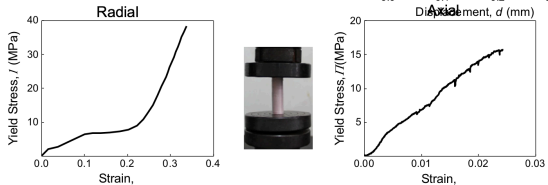


# Experimental Data => Mechanical & Electrical Cell Characteristics

Electrodes and separator compressions



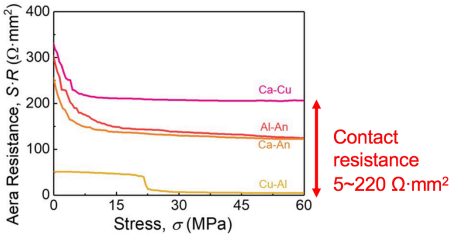
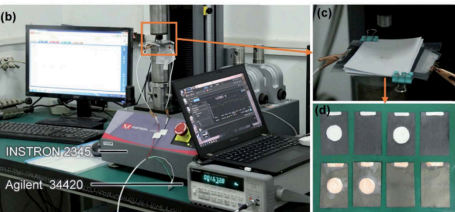
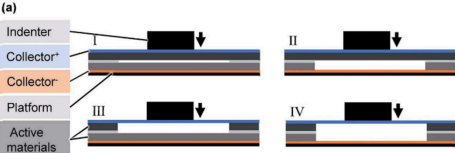
Jellyroll compressions



Mechanical characteristics of the Homogenized material

11

Short circuit resistivity



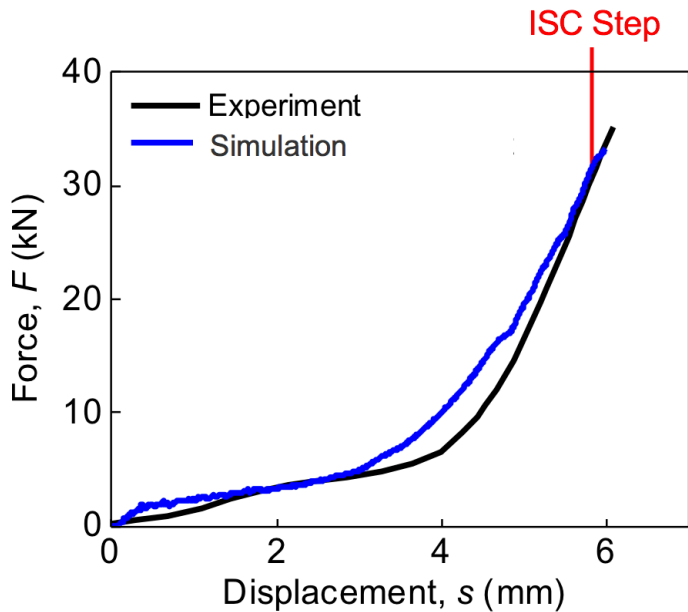
Electric characteristics : short circuit resistivity

- The ISC contact resistance is 5~220  $\Omega \cdot \text{mm}^2$
- Here we choose 220  $\Omega \cdot \text{mm}^2$
- Transfer to the resistivity of separator: 220/0.016=13750  $\Omega \cdot \text{mm}$

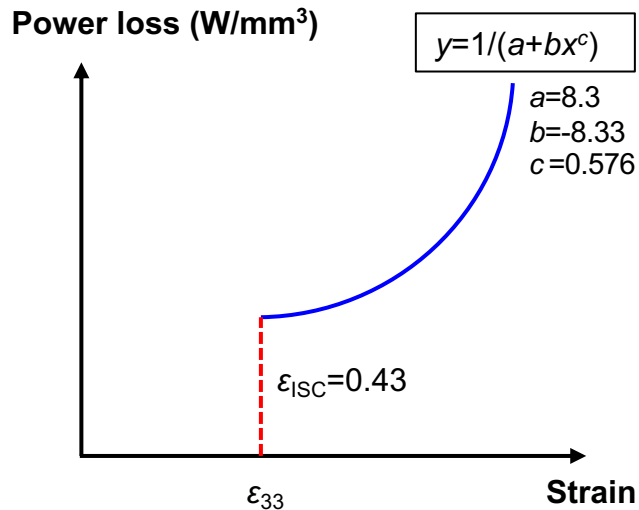


# Power losses curve

Power losses curve due to internal short circuits



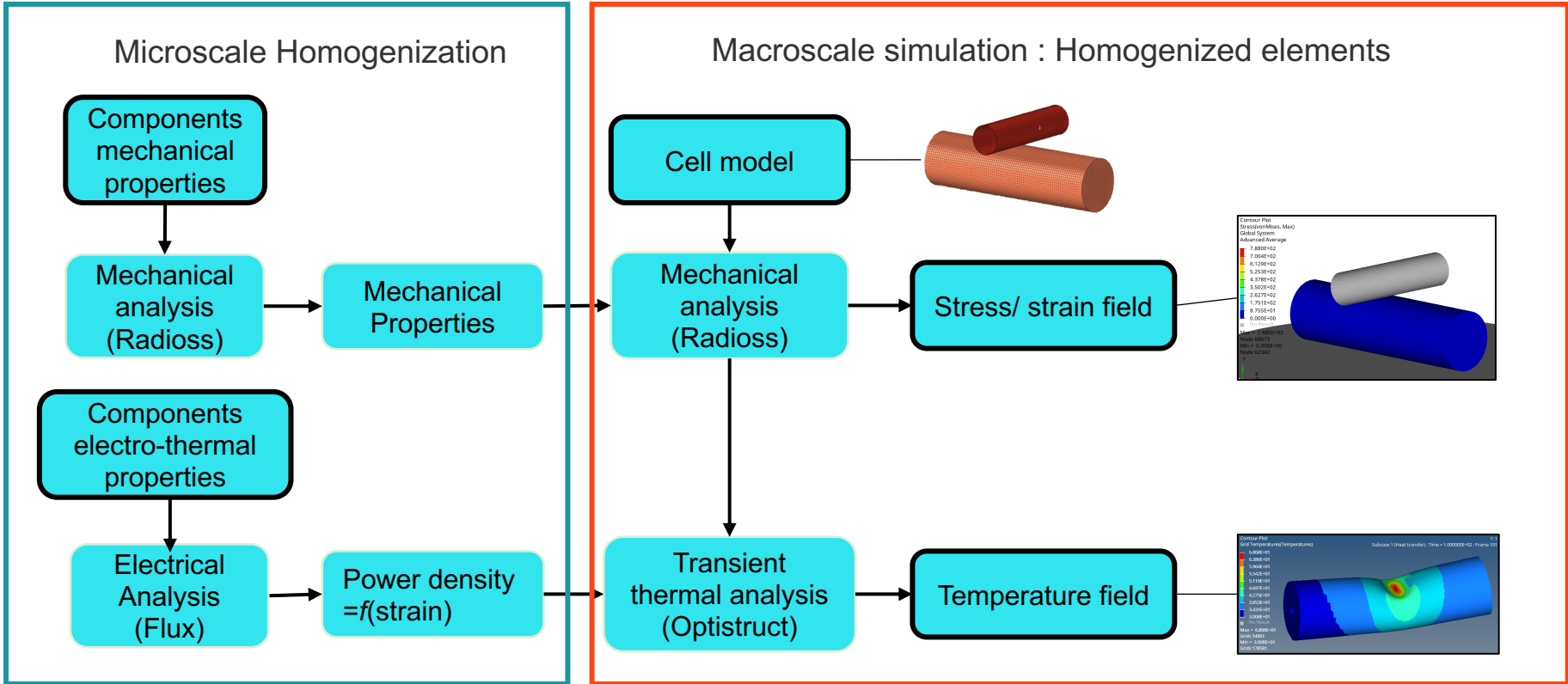
Experimental value => ISC strain 43%



- Strain  $< 0.43$  Power loss = 0
- Strain  $\geq 0.43$  Power loss = curve



# Multiphysics Coupling Methodology

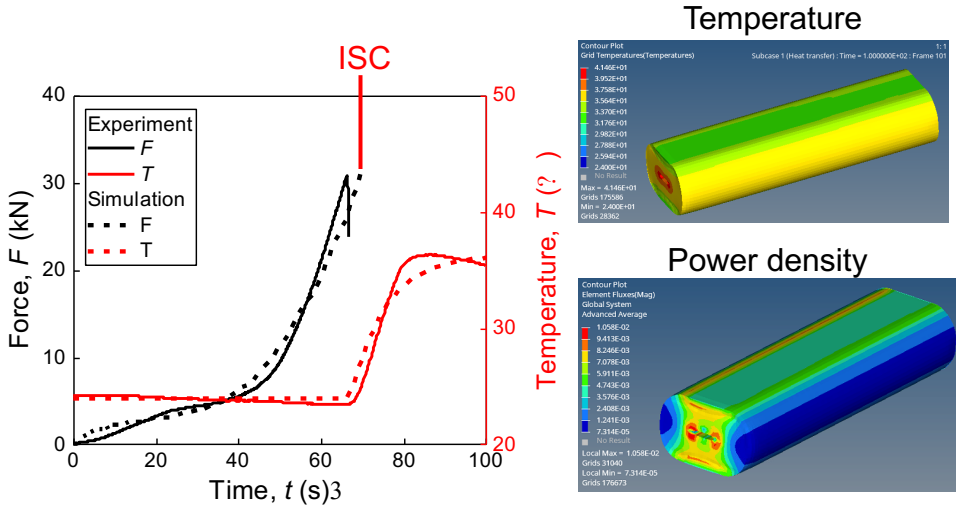




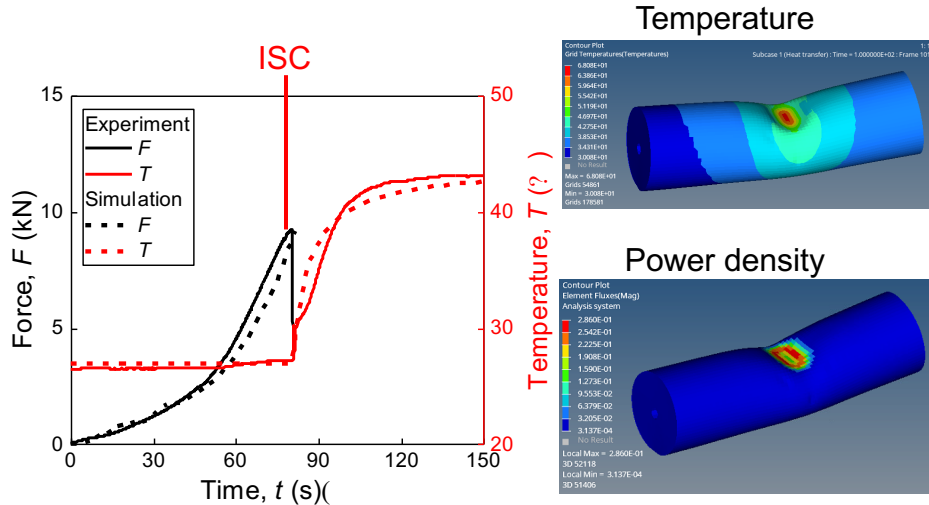
# Thermal results

SOC=0.3, crush velocity =5 mm/min

## Compression



## Indentation



- Model can well predict the experiments in the two loading conditions
  - The three points bending test did not damage with ISC

# ALTAIR BATTERY DESIGNER PROJECT

# “Altair Battery Designer” Consortium

## Develop a battery designer tool to:

- Build a FE model of the battery (cell, module, pack) to improve and/or validate the design of the component complete battery pack under mechanical hazards at short and long terms. Mechanical - Electrical - Thermal behaviors .
- Optimization of the battery components and the pack taking into account the Electrical - Electrochemical - Thermal behaviors - over voltage, ...



Contact Altair for more information

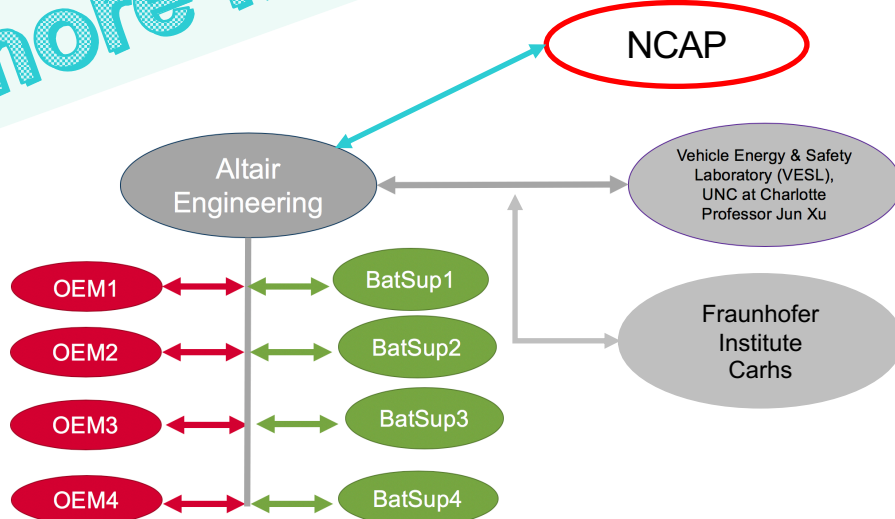
Initial duration : 3 years \*

## Advantages for the members:

- Involved in the R & D
- Access to ...
- ... (tests, simulations)

... usage at the end of the consortium with access to all ... cases during this period \*\*

- Reduction of time to design a battery pack
- Understanding of the multi-physic behavior





# THANK YOU

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#ONLYFORWARD