Improvement of EV battery safety through simulations, tests and advanced components

Making safer batteries by using advanced BMS components and 3D CFD models to predict accidental behavior
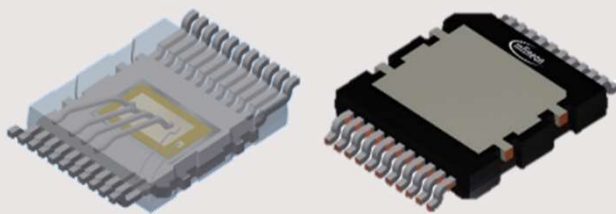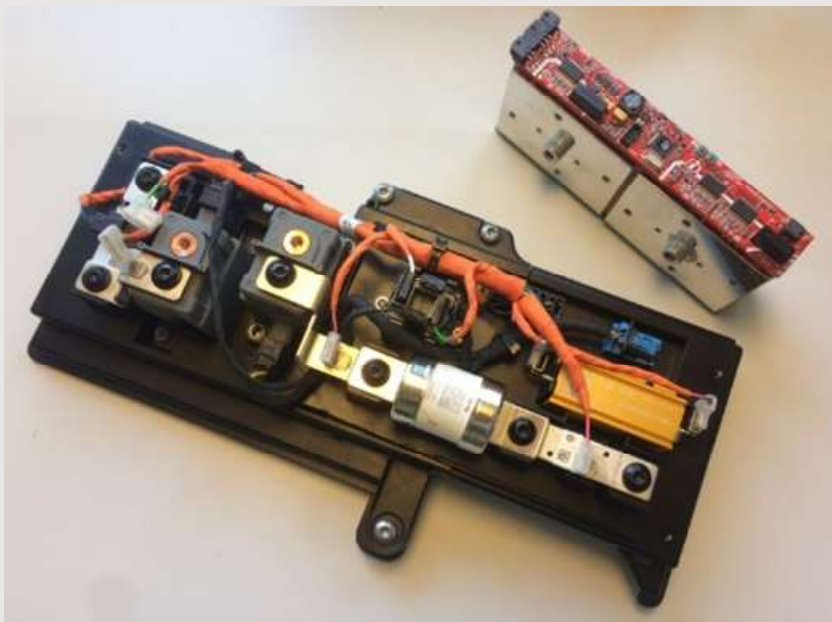
infineon

DEMOBASE

INERIS
maîtriser le risque
pour un développement durable

1 – Improving safety using advanced semiconductor components

Improving safety using advanced components

Prototype of a battery disconnect switch w/ Si- MOSFETS

A new generation of Si Super junction MOSFETs in an innovative top-side cooling package (135mm² cooling area on 15*22 mm² minimum PCB space) improves the required size, reliability & maintenance of battery disconnect switches vs. the conventional mechanical relay solution


Short circuit turn-off test with 5 x 10mOhm 600V MOSFETs:

I ~ 100A per device at Vin=450V w/o destruction

Infineon

INERIS

maîtriser le risque
pour un développement durable
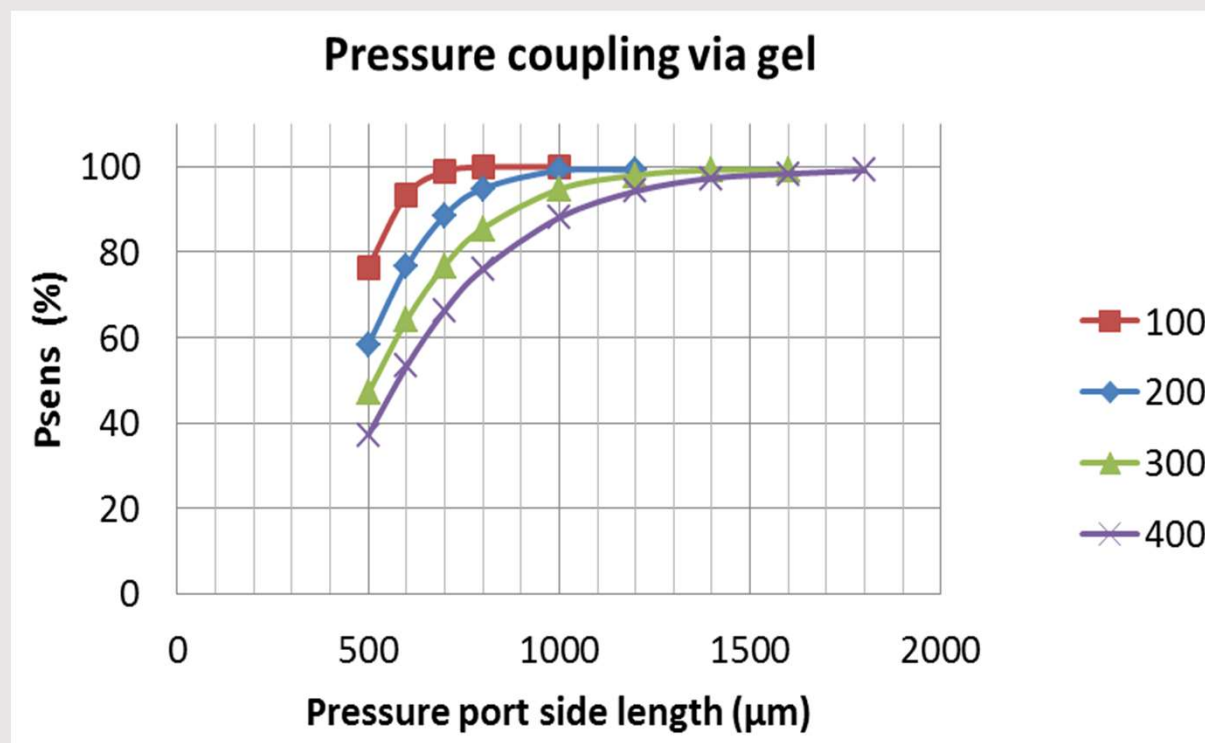
Cell Pressure Sensor

Basic Concept

A modified tire pressure sensor is glued over the filling port of a battery cell, and so in direct contact with the interior of a battery cell
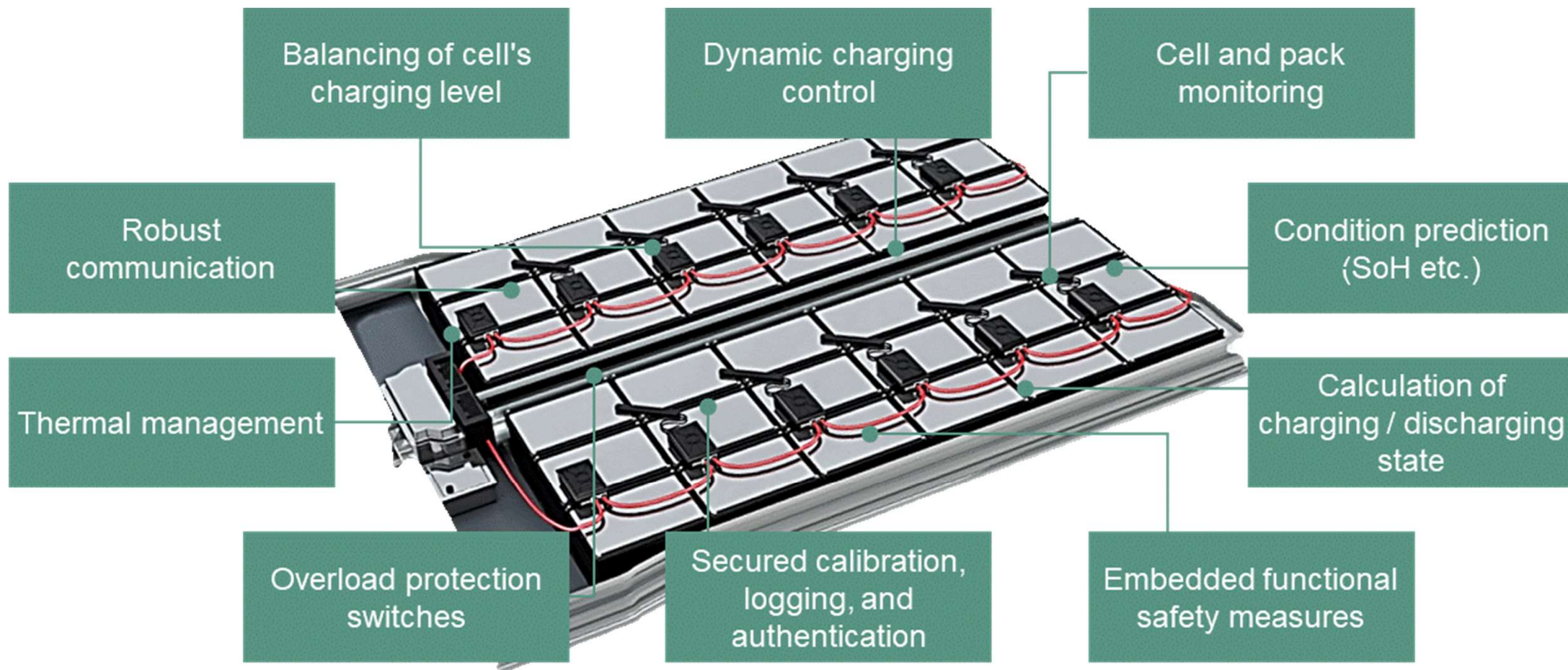

Pressure coupling via gel
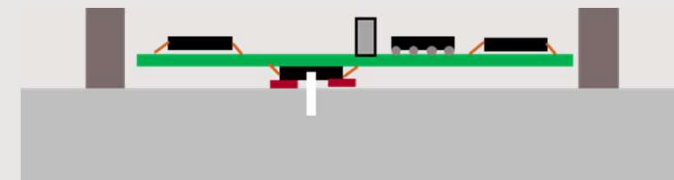
Development work in DEMOBASE

To further passivate the interior of the sensor, and to enable further low-cost solutions, the sensor opening is filled by a gel-plug

Balancing of cell's charging level

Dynamic charging control

Cell and pack monitoring

Robust communication

Condition prediction (SoH etc.)

Thermal management

Calculation of charging / discharging state

Overload protection switches

Secured calibration, logging, and authentication

Embedded functional safety measures

infineon

INE·RIS

maîtriser le risque
pour un développement durable

2- Improving safety using a fail safe approach
CFD modelization of thermal runaway propagation

Several steps to be modelled

1. Ignition in one cell

   ▪ Several complex physical phenomena

   ▪ Depending on the ignition source (internal short-circuit, overcharge, …)

ARC tests
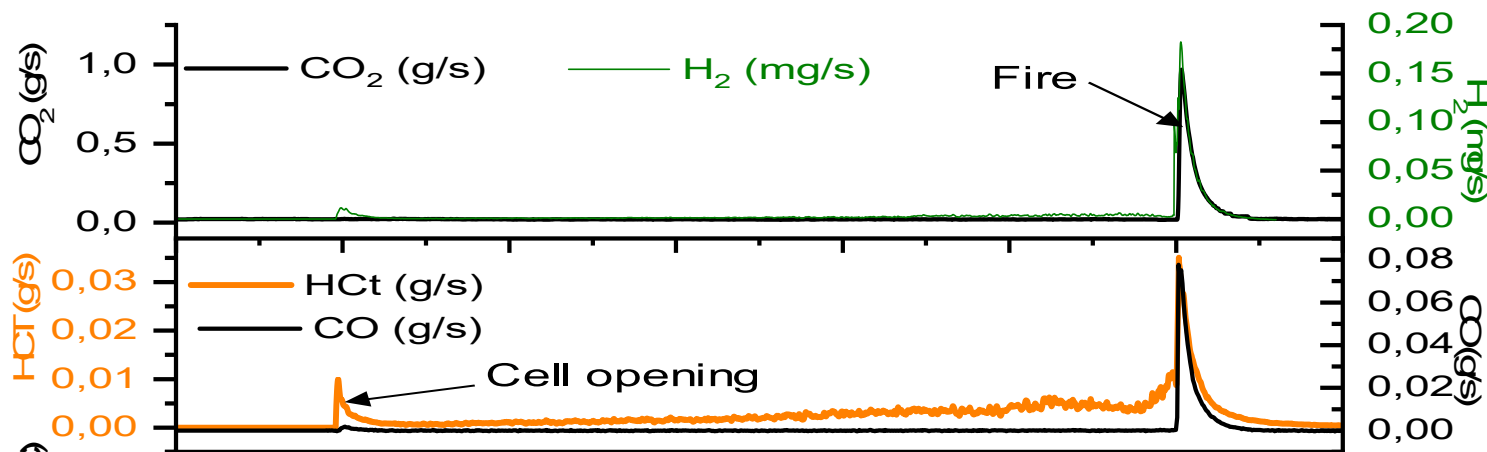
Overcharge tests
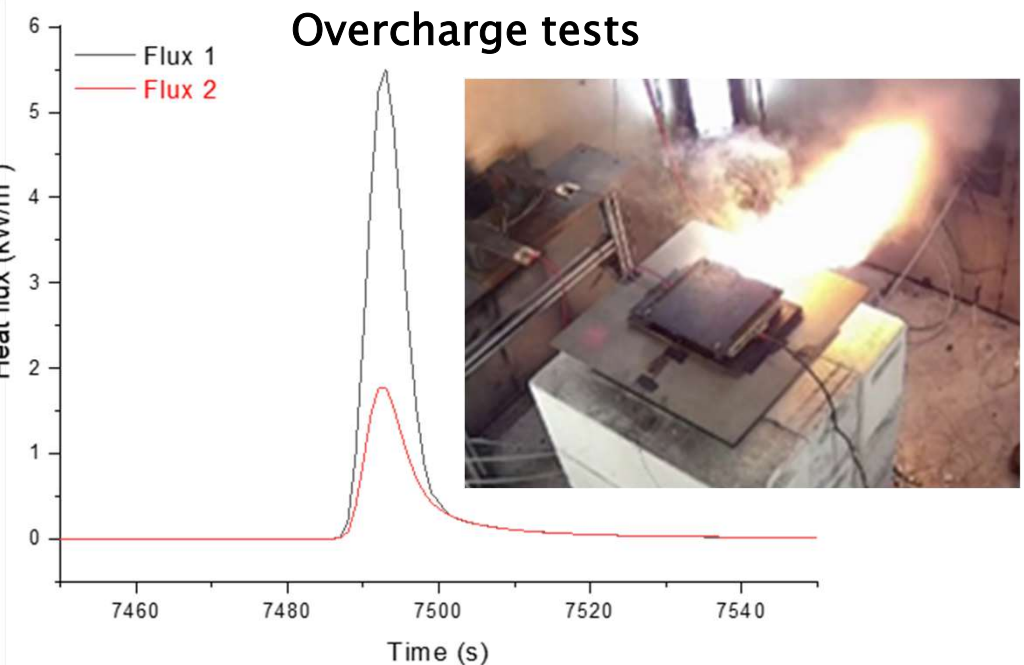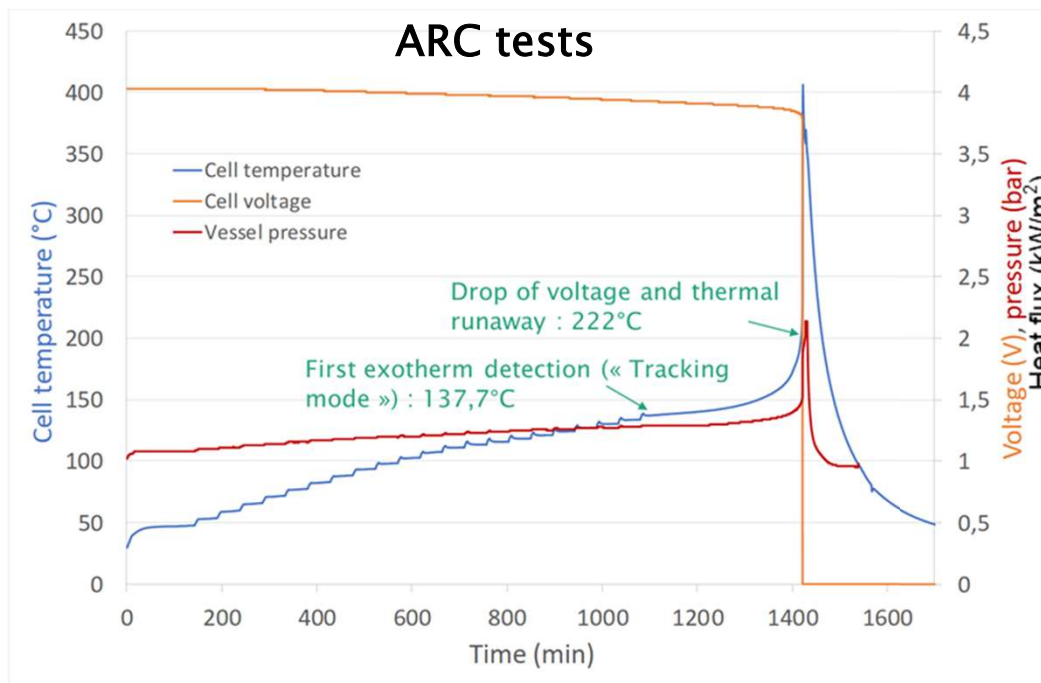
Several steps to be modelled

1. Ignition in one cell
   - Several complex physical phenomena
   - Depending on the ignition source (internal short-circuit, overcharge, …)
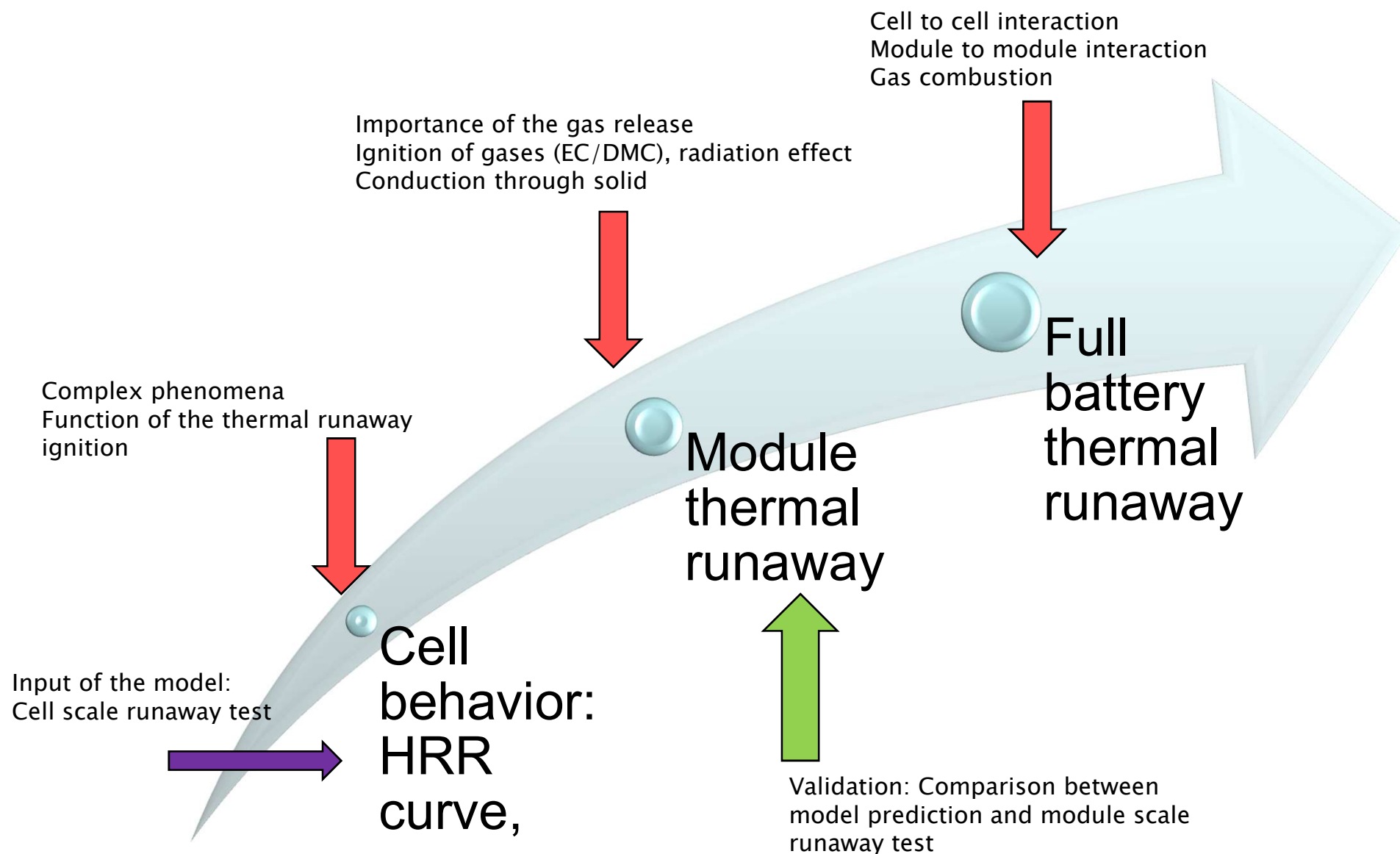
2. Gas release and ignition
   - Mixture of several flammable gases (EC / DMC / …)
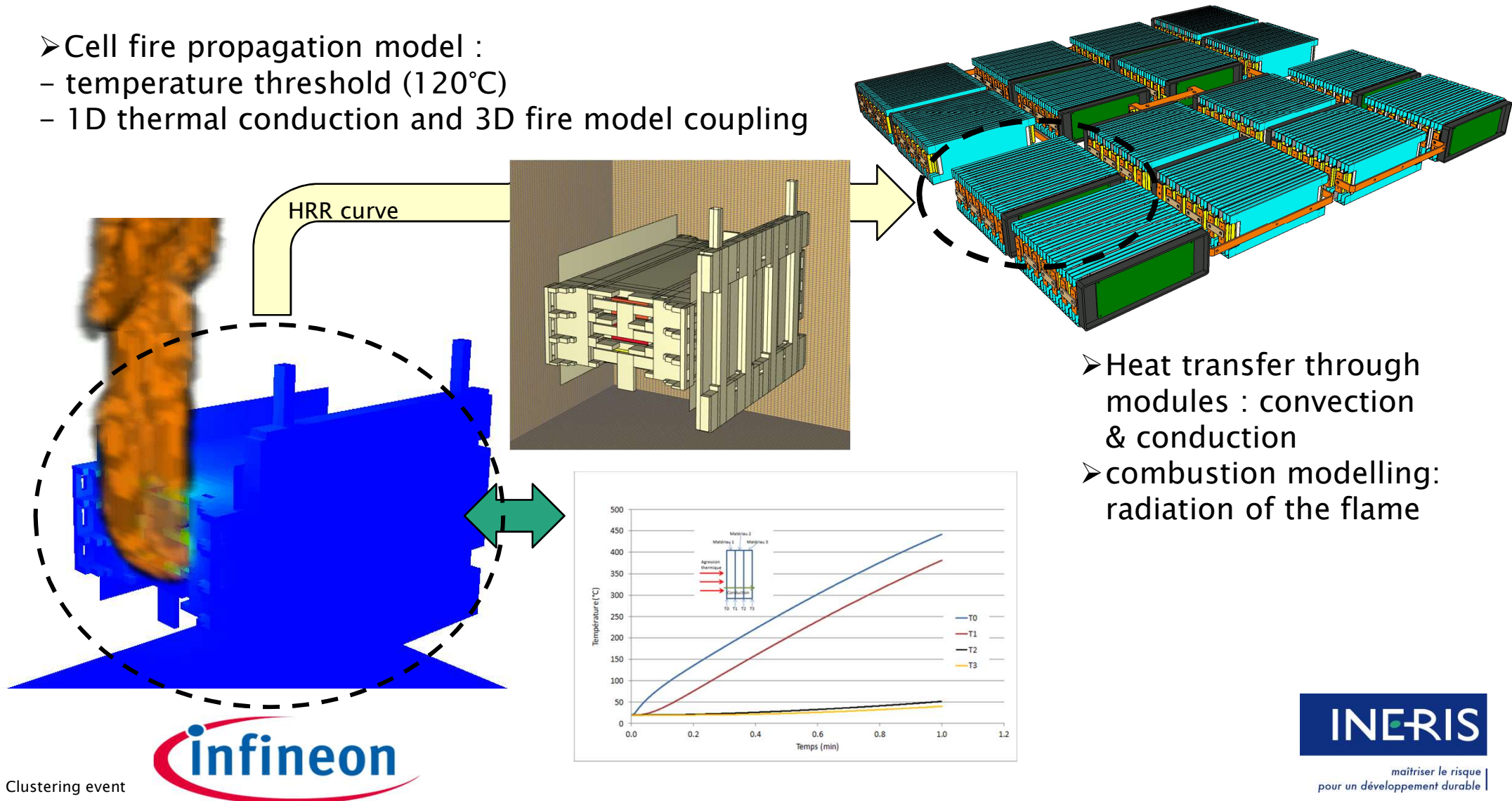
Gas measurement during overcharge tests

Cell to cell interaction
Module to module interaction
Gas combustion

Importance of the gas release
Ignition of gases (EC/DMC), radiation effect
Conduction through solid

Complex phenomena
Function of the thermal runaway
ignition

Full battery thermal runaway

Module thermal runaway

Input of the model:
Cell scale runaway test

Cell behavior: HRR curve,

Validation: Comparison between model prediction and module scale runaway test

INE·RIS

maîtriser le risque
pour un développement durable

Clustering event

Improving safety using a fail safe approach

➢ FireFOAM is a CFD (Computational Fluid Dynamics) tool dedicated to fire modelling developed by an insurance company

➢ Cell fire propagation model :
- temperature threshold (120°C)
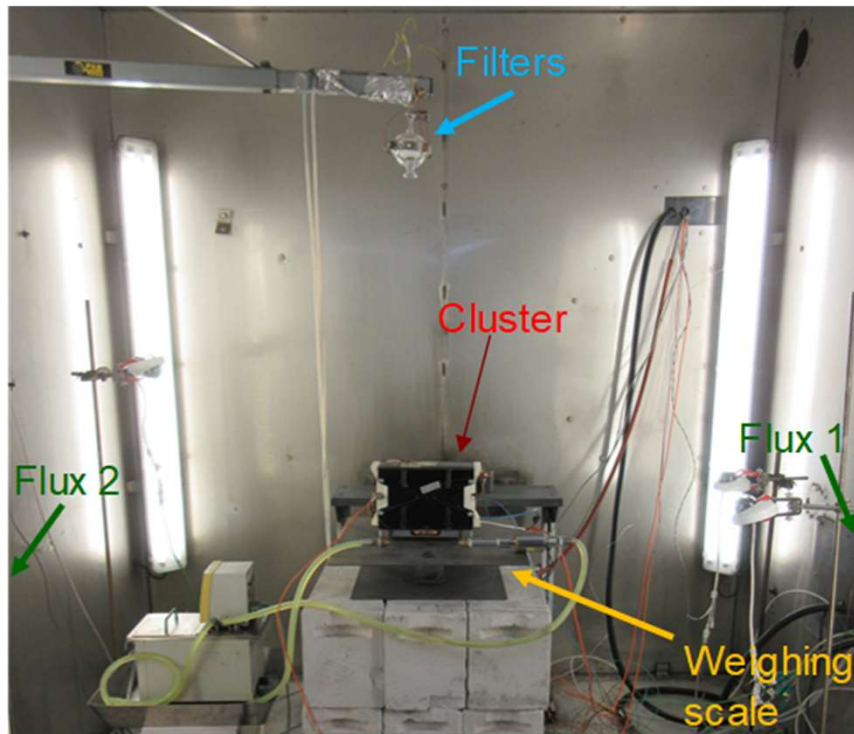- 1D thermal conduction and 3D fire model coupling

HRR curve

➢ Heat transfer through modules : convection & conduction
➢ combustion modelling: radiation of the flame

2– Improving safety using a fail safe approach
Experimental validation

Improving safety using a fail safe approach

Filters

Cluster

Flux 2

Flux 1

Weighing scale

Clustering event

Thermal runaway of the central cell

Thermal runaway of the 2nd (and 3rd?) cells

Heat of combustion

HRR

Max HRR = 24,4 kW
Total heat of combustion = 1,13 MJ
Overall energy released per unit mass loss = 2,2 kJ/lost g

INERIS

maîtriser le risque
pour un développement durable

Acknowledgments