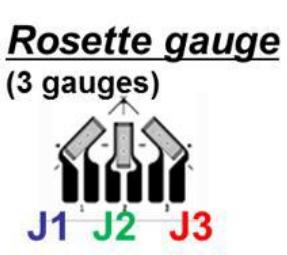
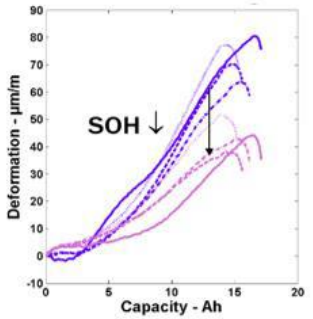
Electrical cycling with sensors (CEA, ZSW, VITO) (T25):

During cycling of Li-ion cells, many different parameters change simultaneously, such as voltage, resistance, pressure, dimensions, and temperature. ZSW, CEA and VITO will develop novel cell setups able to acquire one or several of these parameters in real-time during cycling and calendar ageing. This technique will provide deep insights into the performance and aging mechanisms of Li-ion cells implementing new materials. This technique will help to optimize material combinations & operational parameters to enhance lifetime and performance significantly. Generated data will also help to improve the understanding of the ageing mechanisms and effects of materials, cell design, and packaging.

Fast charging is a challenge for automotive batteries, due to the high current and associated temperature gradients that can lead to premature ageing or even thermal runaway. Accurate modelling of intra cell temperatures during fast charging will allow a better compromise between ageing and charging speed. **The temperature gradients will be measured using a Bragg grated fibre introduced into variously shaped cells.**

Existing models can assist us in determining safe charging voltages in anode controlled charging techniques, but these models are often not validated and don't allow for needed safety margins. Therefore, we propose to instrument commercial **Li Ion cells with a reference electrode** against which, after correction for the Li-H potential, the anode and cathode potentials can be measured. This must be done in a number of relevant operating points in order to validate the models and determine safety margins. Once the models are reliable, they can become a crucial part of fast charging algorithms.





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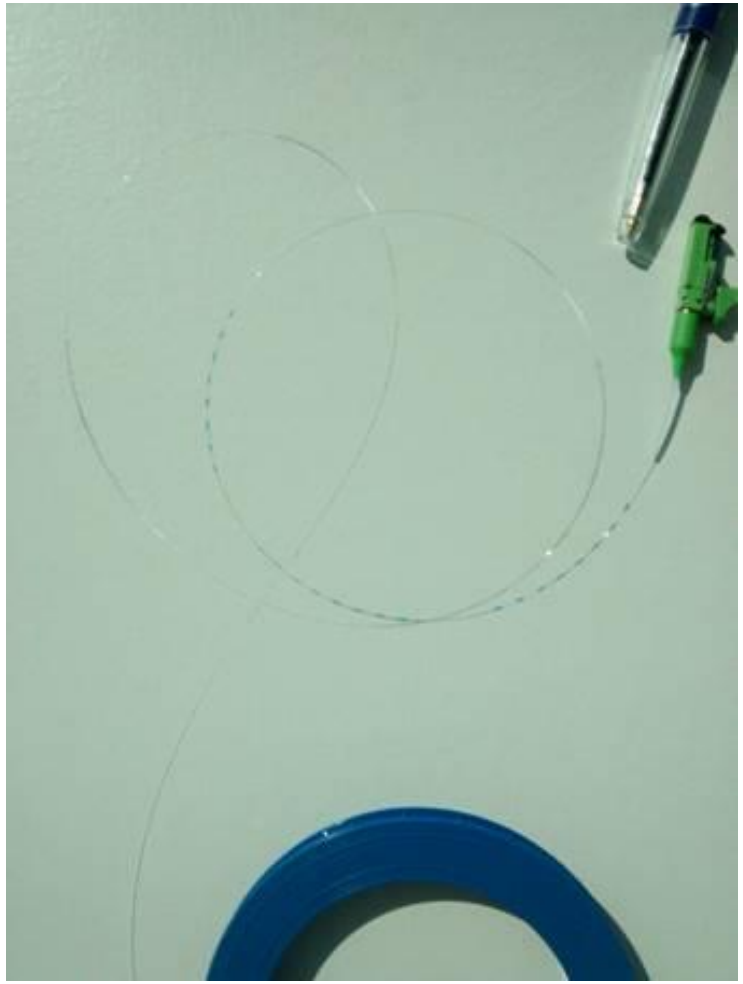

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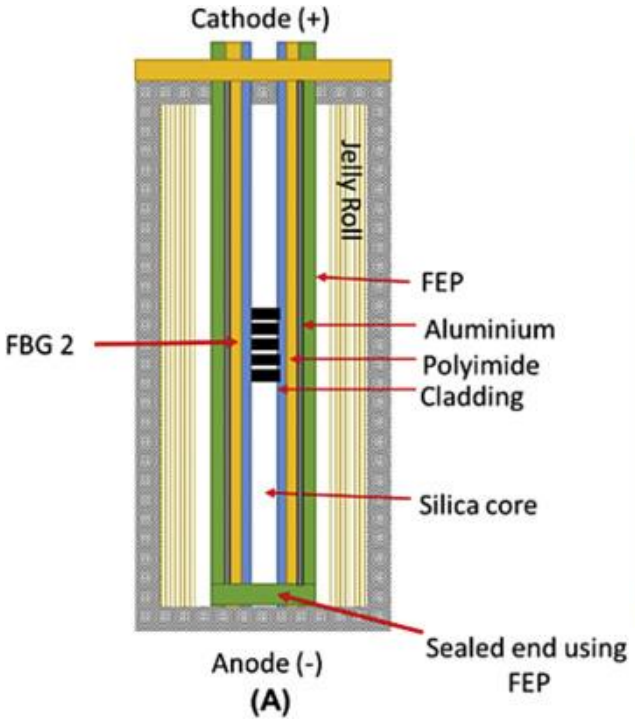
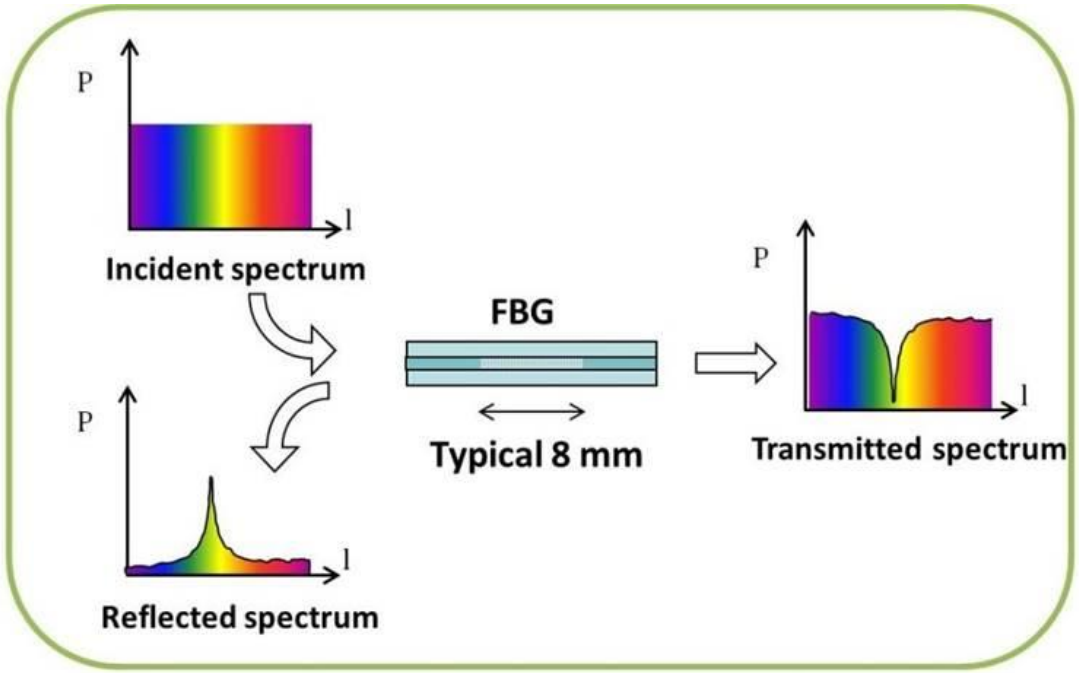
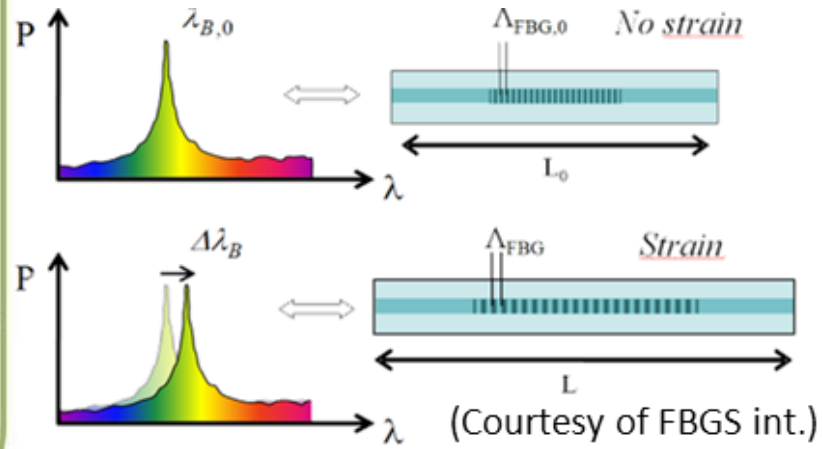






Strain& temperature response are intertwined (same reaction to both separately and/or combined)

Electrochemical cycling with sensors
Temperature (strain) with Bragg fibres

What can we characterize : cells

Experimental time: 1 day or longer

Advantage: a way to observe inside temperature and its distribution (strong ageing effect due to inhomogeneity). Important for (BMS) model verification and for high power load on cells.

Drawback: Fibre must be added in production or afterwards (tricky).

R&D Status: Under development

FROM RESEARCH TO INDUSTRY

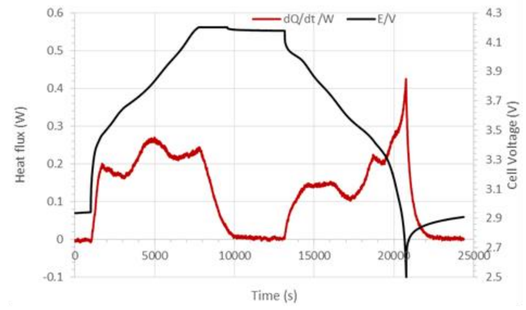
cea tech

liten

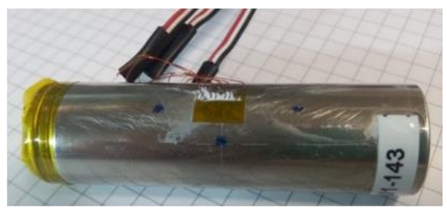
MULTI SENSING MONITORING OF BATTERIES ?(T25)

What ?

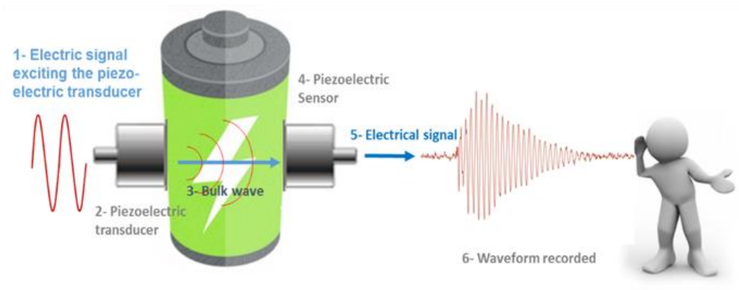
Heating: thermocouple, heat flux sensors



Deformation: strain gauge



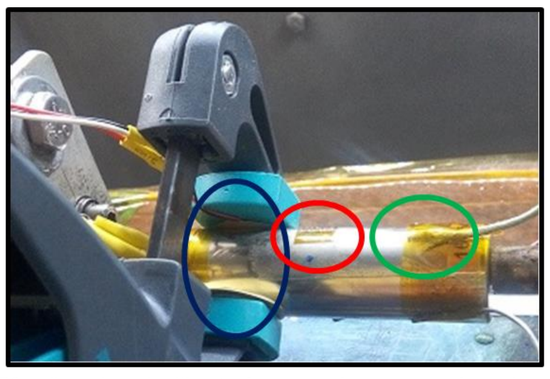
Physical change of materials: Acoustic interrogation



Why ?

- ❑ Normal conditions of operation
- ❑ Abusive conditions / safety testing campaign
  - External short circuit
  - Overcharge
  - Thermal stability

➔ Over heating, gas formation, swelling …

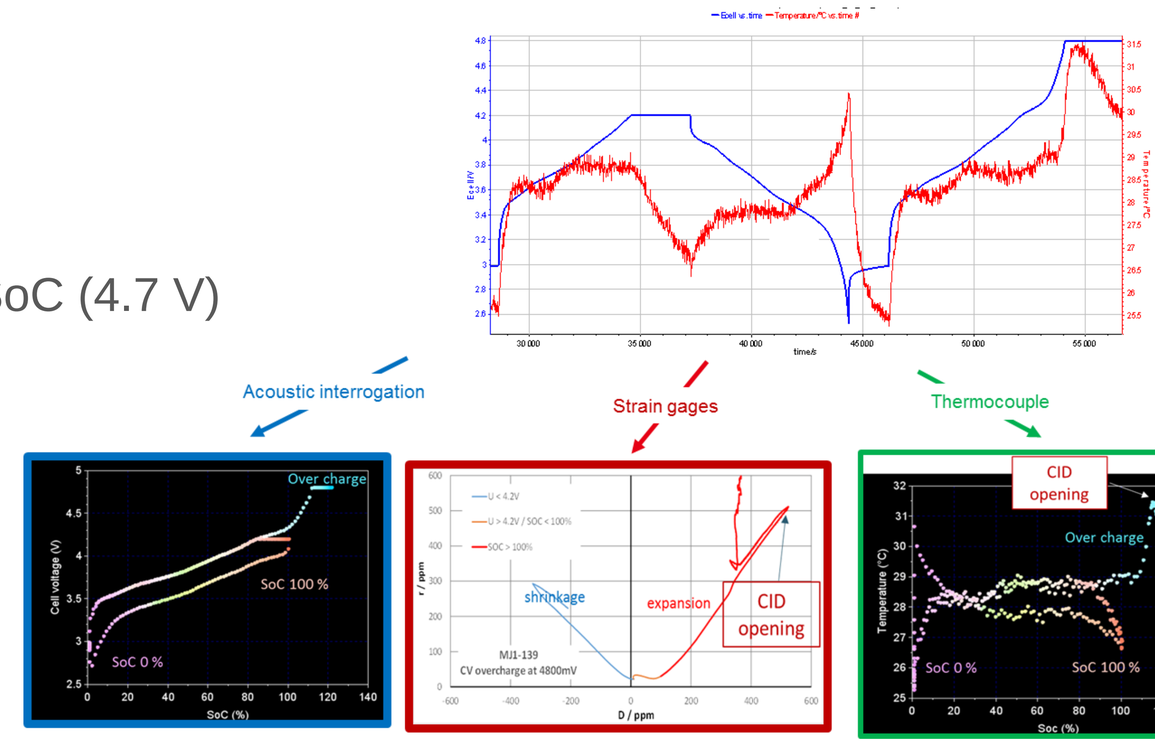


18650 cell equipped with **strain gage**, **thermocouple** and with **two piezo-electric transducers** (acoustic interrogation).

Example of results

- ❑ Normal cycling and overcharge (up to 4.8 V)
  - Cylindrical expansion during overcharge
  - Temperature increases sharply (+ 2.5 °C) above 110 % SoC (4.7 V)
  - CID opens at Ucell > 4.8 V (for all C-rates) at 114 % SoC
  - Overcharge = abnormal evolution of the acoustic signals

↳ **Detection of early signs of abnormal behavior.**



Example of the evolution of acoustic waves during cyclin at different rates of a 18650 battery.

Main potential use:

- Optimal operation range (minimize stress)
- Detection of defects / Quality
- Advanced BMS for better performance and safety
- Safety (abusive test, detect early signs)

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Advantages:

- ❑ Multi-sensing monitoring, very useful for batteries characterization.
- ❑ Usable in normal condition of operation or in abusive conditions tests (mild or destructive conditions)
- ❑ Identification of ageing mechanisms from observed phenomena.
- ❑ Advanced BMS for better performance and safety

Drawbacks:

- ❑ A lot of sensors = a lot of wires !!!

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