FROM RESEARCH TO INDUSTRY

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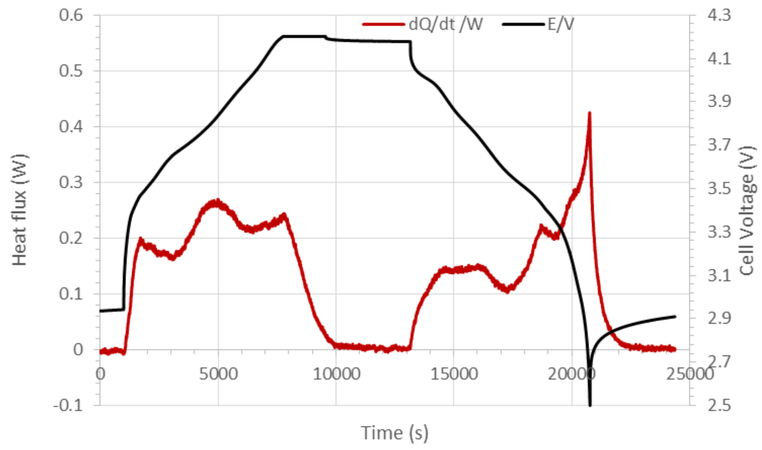
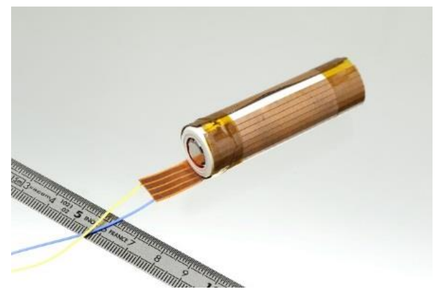
HEAT FLUX SENSORS (T21)

TEESMAT

What ?



Example of cell voltage and heat flow measured on a 18650 battery during charge (CC at C/2 and CV) and discharge (C/2).

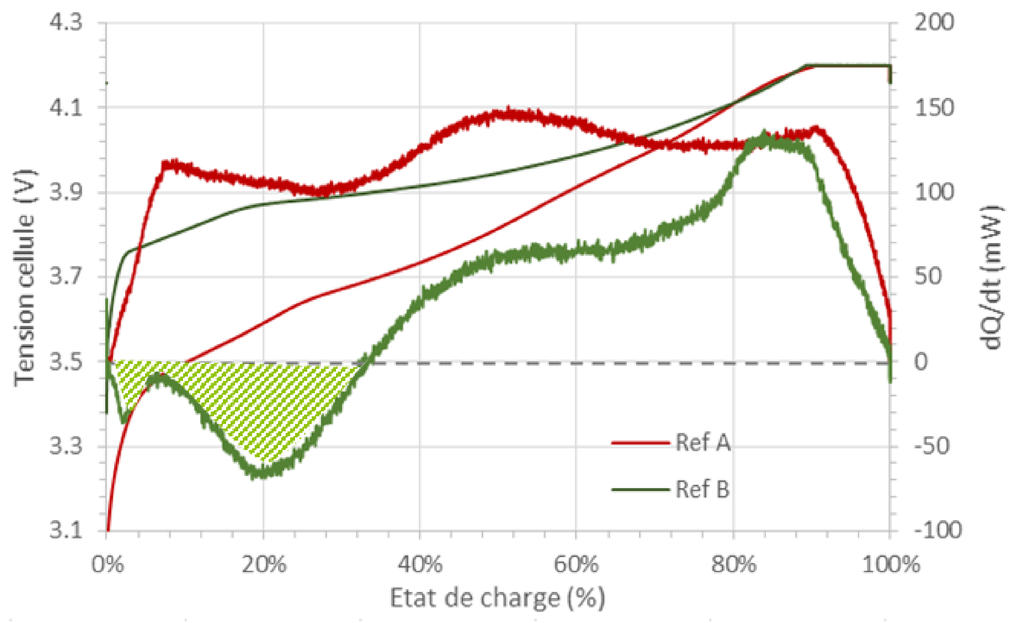


Heat flux sensor wrapped around a 18650 battery

- ❑ How much heat is exchanged with the surrounding during operation?
- ❑ Influence or the C-rate / mission profile ?
- ❑ Influence of the surrounding temperature and the casing / thermal management ?
- ❑ Thermal properties (heat capacity measurement) ?

Why ?

- ❑ External setup, does not interfere with the normal operation
- ❑ Easy to put in place on any types of battery and battery cells
  - ➔ Quantify the amount of heat exchanged with the surrounding
  - ➔ Detect abnormal thermal behaviors (aging, abusive tests)



Example of cell voltage and heat flux measured on two 18650 batteries during charge (C/3). Endothermic phenomenon occurs at the beginning of the charge of Ref. B (not on Ref. A).

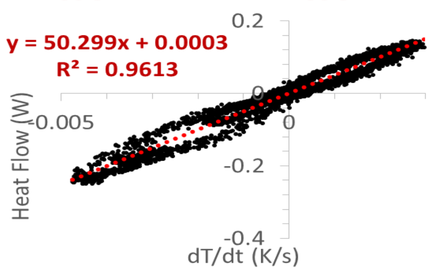
Example of results

- ❑ Direct measurement of the heat flow exchanged with surrounding
- ❑ Thermal monitoring and management
- ❑ Easy way to measure the Cp of the battery

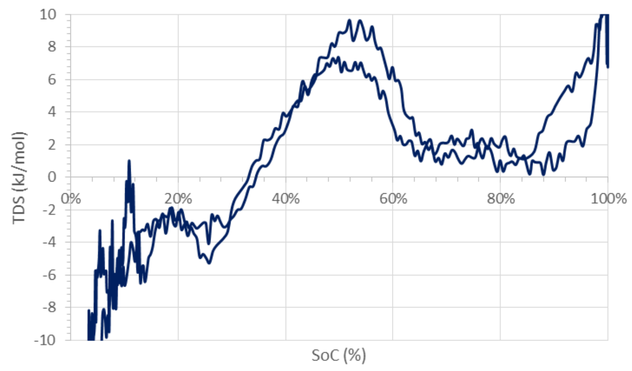
➔ Very different thermal behavior (need to adapt the temperature management strategies);

➔ Thermal signature specific to each type of battery (chemistry).

$$\frac{dQ}{dt} = mC_P \frac{dT}{dt}$$



Easy way to measure of the Cp;



Direct calculation of the entropic term (TΔS).

Main potential use:

- Characterization (thermal behavior, ΔS)
- Thermal modeling (Cp)
- Temperature management strategies
- Safety (abusive test, detect early signs)

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Advantages:

- ❑ Very simple and useful technique for batteries characterization
  - Non invasive and operando technique / Easy to put in place
  - Direct measurement of heat exchanged with surrounding
  - Easy way to measure the thermal behavior used for modelling and sizing of the cooling system
- ❑ Battery monitoring and management
  - Detection of early signs of abnormal thermal behavior
  - Thermal management for better performance and safety

Drawbacks:

- ❑ Various sizes of heat flux sensors, sensitivity can vary
- ❑ Heat exchanged by the connexion to the power connectors (and busbars) is not measured

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