Calorimetric measurements of batteries using gSKIN® Heat Flux Sensors

November 2015, Zürich, Switzerland

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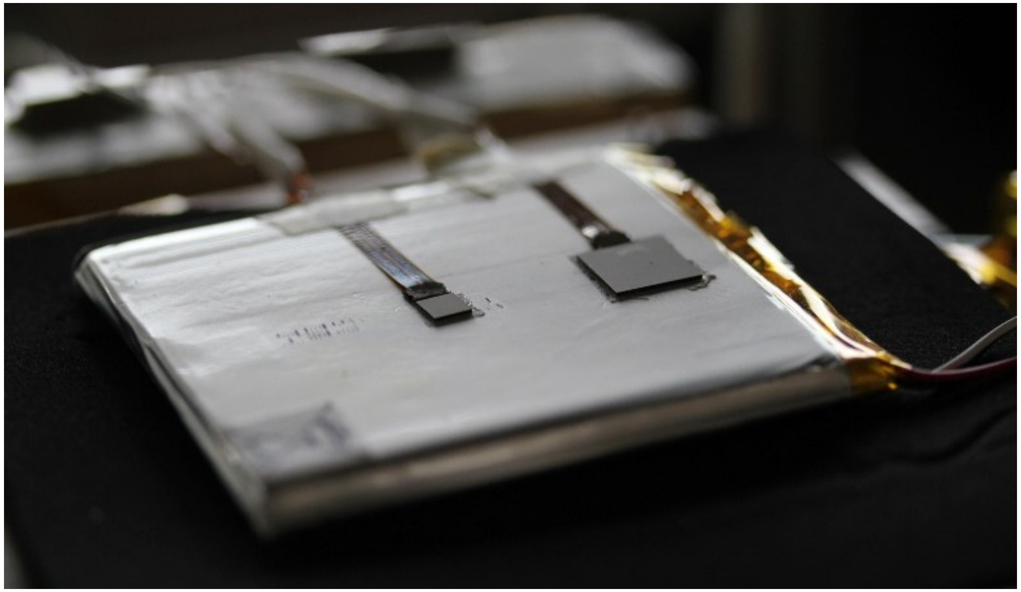
Introduction

For understanding the thermal behavior of batteries heat flux sensors can be applied. Today, most thermal measurements of the batteries are conducted with use of temperature sensors and/or battery calorimeters. However, this approach es can either be unreliable, time consuming or very costly. With greenTEG's heat flux sensors, calorimetric measurements become feasible and affordable.



Example: Integration of gSKIN heat flux sensors into a measurement setup

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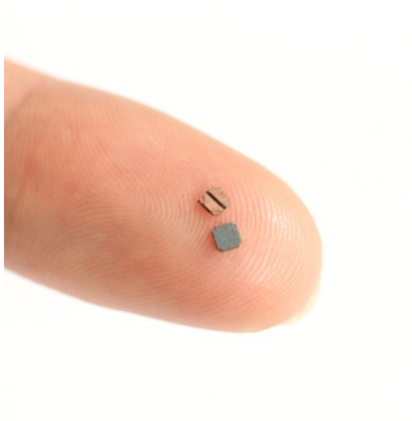
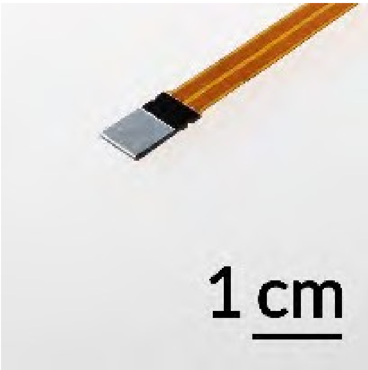
Advantages of gSKIN® heat flux sensors

- Small size heat flux sensor (e.g. 4.4 x 4.4 mm) with high sensitivity, easy to use on pouch and cylindrical cells
- OEM sensor (2mm x 2mm) for prize sensitive high volume products are available on request
- Measures heat (Q-value) into and from the battery directly
- Entropy profiling become feasible (footprint for SOH determination)
- Space resolved measurements
- Increased detection speed and reduced uncertainties in end of line testing



OEM Sensor 2mm x 2mm



XM retail sensor: 4mm x 4mm

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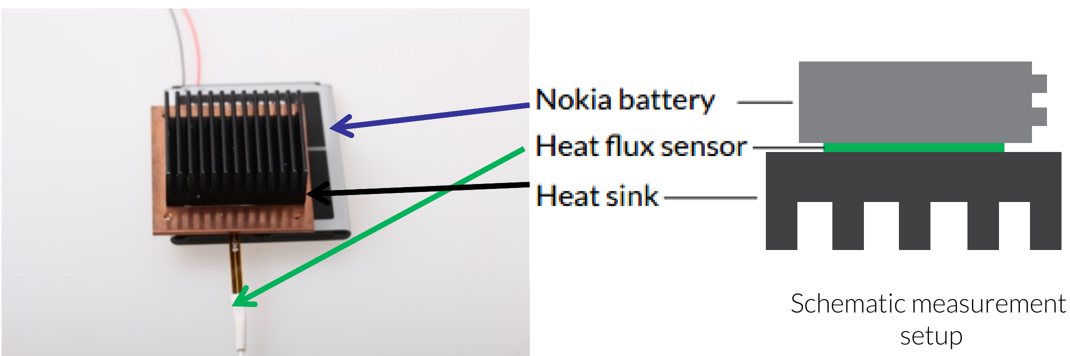
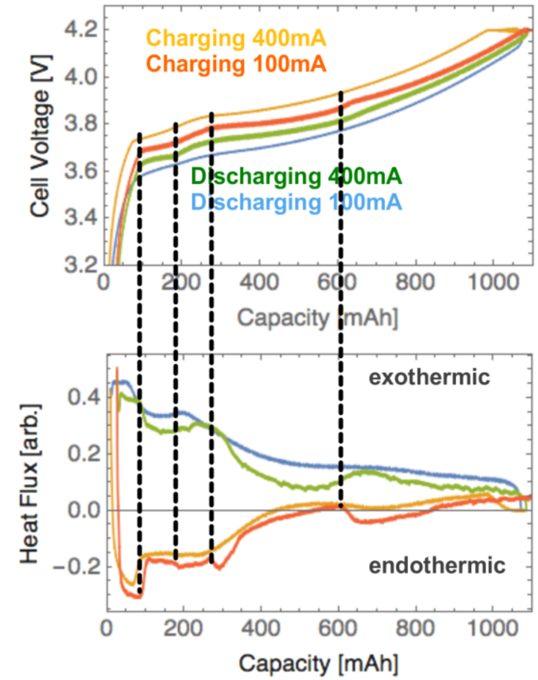
Application 1: Measuring entropy profile in batteries

Easy to use for entropy profiling at the battery surface

- SOH determination
- End of line testing
- Life time and aging investigations
- Detection of electrode disbalancing



Schematic measurement setup



These results show that highly resolved entropy profiles can be recorded

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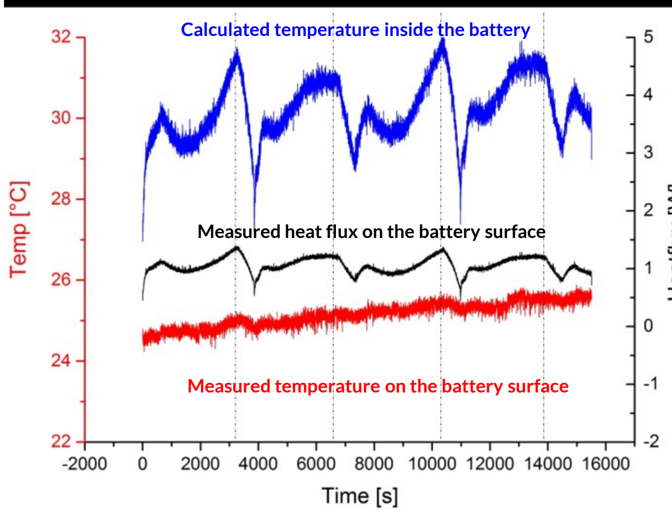
Application 2: Measuring of the inner temperature

Dr. Lukas Durrer (greenTEG AG) evaluated the use of gSKIN®-XP heat flux sensor for determination of the **thermal capacity of batteries** and as well as the **thermal conductivity** and **inner temperature** of the battery in use.

[redacted]



Video showing complete setup and measurement results
https://www.youtube.com/watch?v=D2uP4vNrrFY

Heat flux (black) and temperature response (red) measured at the battery surface. The temperature inside the battery (blue) is determined by knowing the heat capacity and thermal resistance of the battery

Application 3: Battery manufacturing equipment improvement

Research from the department of Thermal Process Engineering at the Karlsruhe Institute of Technology has shown, that with use of greenTEGs sensors space resolved heat transfer coefficient in thin-film dryer can be determined. Such an approach helps improving the quality of electrode production drastically.

Baunach, M. et al. (2015): „Local heat transfer characteristics of a slot nozzle array for batch drying of thin films under industrial process conditions". Journal of Coatings Technology and Research

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Q&A regarding thermal characterization of batteries using heat flux sensors is available on our website

Our webshop

Starter Kit

Heat Flux Sensor Starter Kit (ideal for thermal characterization of batteries)
Size: 4.4mm x 4.4mm and 10.0mm x 10.0mm
Resolves 0.4 W/m^2 - 9 µW - 140 µK

Features

- Ultra-high resolution of thermal energies and temperature differences
- Low invasiveness and thickness
- For space resolved measurements, SOC control, life-time observation and BMS
- All sensors with conductive heat flux calibration cohering to ISO 8301
- Applications: R&D, thermal optimization, energy efficiency, industrial monitoring of thermal properties

Downloads

- gSKIN® Heat Flux Sensors Datasheet
- gSKIN® Heat Flux Sensors Instruction Manual
- Case Study: Battery calorimetry using
- Q&A: Thermal characterization of batteries using heat flux sensors

gSKIN® Starter Kit	
Article Number	Starter Kit
Detector Type	Thermoelectric
Surface Material (Sensing Area)	Aluminum
Sensing Dimensions (a x b x d) [mm x mm x mm]	4.4 x 4.4 x 0.5 and 10.0 x 10.0 x 0.5
Heat Flux Range Min / Max [kW/m^2]	-150 / 150
Noise Equivalent Heat Flux [a] per area [W/m^2] / absolute [µW]	0.340 / 6.6 and 0.073 / 7.3
Heat Flux Resolution per area [W/m^2] with gSKIN® DLOG [b] / absolute [µW]	0.41 / 7.9 and 0.09 / 9.0
Temperature Difference Resolution [µK]	~140 and ~30
Min. Sensitivity (S) [µV/(W/m^2)]	1.5 and 7.0
Temperature Dependence of S [%/°C]	0.25
Response Time (0-95%) [s]	0.7
Electrical Resistance [Ohm]	< 20 and < 100
Absolut Thermal Resistance [K/W]	~18.0 and ~3.5
Max. Compressive Force when clamped [kgf]	< 2 and < 10
Operating Temperature Range Min/Max [°C]	-50 / 150
Calibration Temperature Range Min/Max [c] [°C]	-30 / 70
Calibration Accuracy [±%]	3

Q&A for battery setup

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Q&A: Thermal characterization of batteries using heat flux sensors

What kind of data logger do I need for my measurements?

For high resolution measurements, you need a data logger which can resolve at least 1uV. For synchronized measurements (for example channel 1 cell voltage, channel 2 heat flux voltage measurement) it is often useful to plug the sensor to the A channel of the multichannel potentiostat.

How do I mount the heat flux sensor?

Important when attaching the sensor to the battery surface is optimal thermal connection. We therefore recommend cleaning the surface of the sensor and the battery with Isopropanol. Then the sensor can be attached by either a double side sticky thermal tape, or by pressing the sensor to the surface using thermal paste or by gluing the sensor to the surface with a thermally conductive epoxy. The sensor needs to be removed carefully. Do not pull at the flex-print! It is better to remove the sensor by a blade and Isopropanol.

Which sensor is better, the XM or the XP?

This depends on the application. The advantage of the XM sensor is its small size of 4mm x 4mm, while with the larger XP sensor a higher resolution can be obtained (below 0.09W/m2). We propose that you test both so you can find out which one is best suited for your application.

Can the sensor be used in water?

We have done several experiments in deionized water without any problems. The highly accelerated stress tests at a humidity of 85% and a temperature 125°C for 100h do not show any sensor degradation.

Could the sensor be used inside the battery?

We do not have any experience with this kind of experiments yet. You can try to do tests at your own risk. However the sensor is very robust against chemicals. For this kind of experiment we suggest to seal the borders and the contacts of the sensors with chemically stable glue. If you need a longer flex-print for insertion into the battery, just ask for an additional flex-print. You can attached this flex print to the flex-print of the sensor by using a solder paste, pressing the tow contacts onto each other and heating it with a solder gun from top. Please make sure that you seal the position of the connection also by chemical inert glue.

How are the sensors calibrated?

The sensors are calibrated in a special measurement setup using NIST traceable thermal reference materials. For further information see: http://scitation.aip.org/content/aip/journal/rsi/83/7/10.1063/1.4737880

Please do not hesitate to contact us at info@greenTEG.com if you have any questions.

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Resources at a glance:

(1) Case study: Battery calorimetry using greenTEG's heat flux sensors

(2) Case study: Monitoring heat generation of batteries

(3) greenTEG Q&A Thermal characterization of batteries using heat flux sensors

(4) Baunach , M. et al. (2015): „Local heat transfer characteristics of a slot nozzle array for batch drying of thin films under industrial process conditions". Journal of Coatings Technology and Research

Additional literature:

http://jes.ecsdl.org/content/149/8/A978.full.pdf

http://www.sciencedirect.com/science/article/pii/S0378775314011719

http://www.ethlife.ethz.ch/archive_articles/131017_li-ion-battery_per/index

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