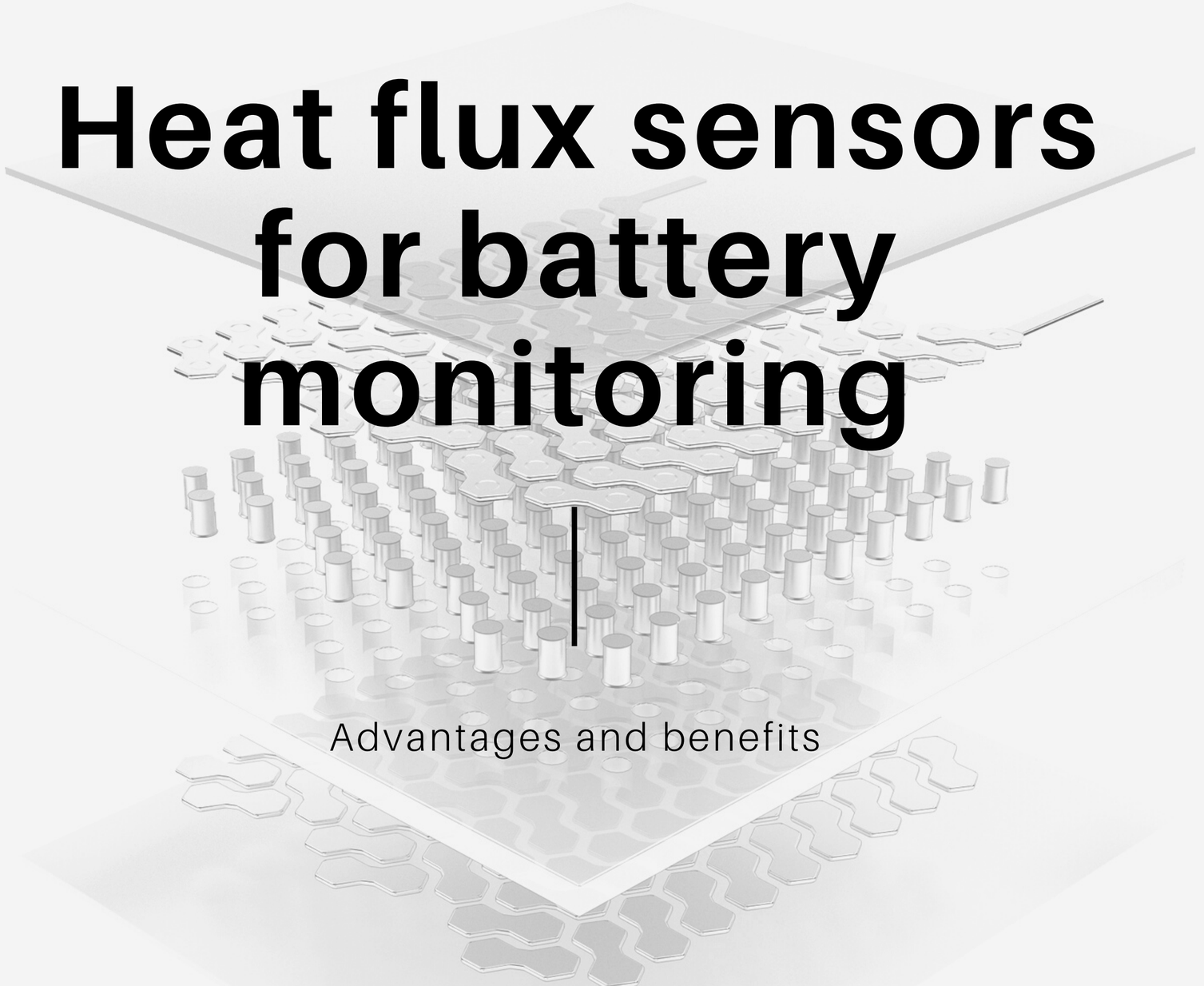
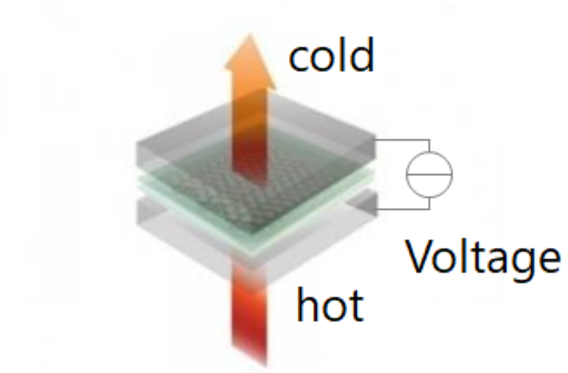
Heat flux sensors for battery monitoring



Advantages and benefits

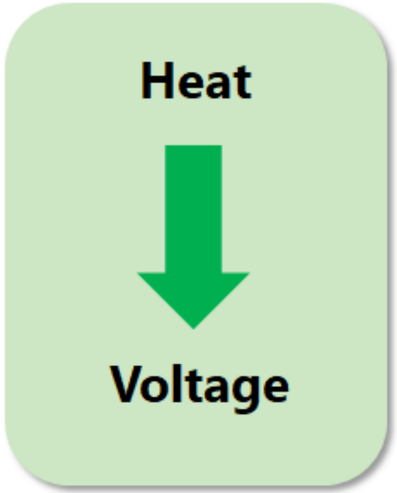
A brief explanation of heat flux sensing.

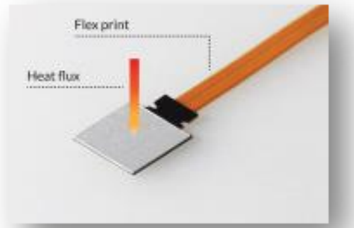
Heat Flux sensors use the Seebeck effect to accurately measure heat transfer processes.



Principle

Heat flux sensor





Device

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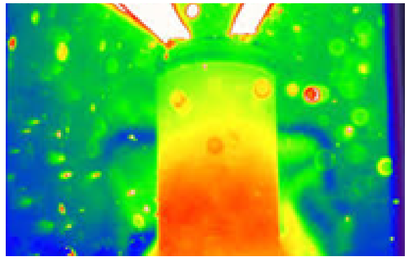
Heat flux sensing has several potential applications for battery research

Thermal runaway prevention.

Status control.



Thermal management.

Battery quality control.

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Thermal runaway prevention.

Problem:

- **The inner temperature of the battery should not exceed 60° C**
- **The inner temperature of the battery can not be monitored with surface temperature sensors**

Solution: Calculate the inner temperature by combining the heat flux sensor signal with a surface temperature sensor signal

$$T_{inside} = T_{surface} + Q*R$$

R = Thermal resistance
Q= Heatflux

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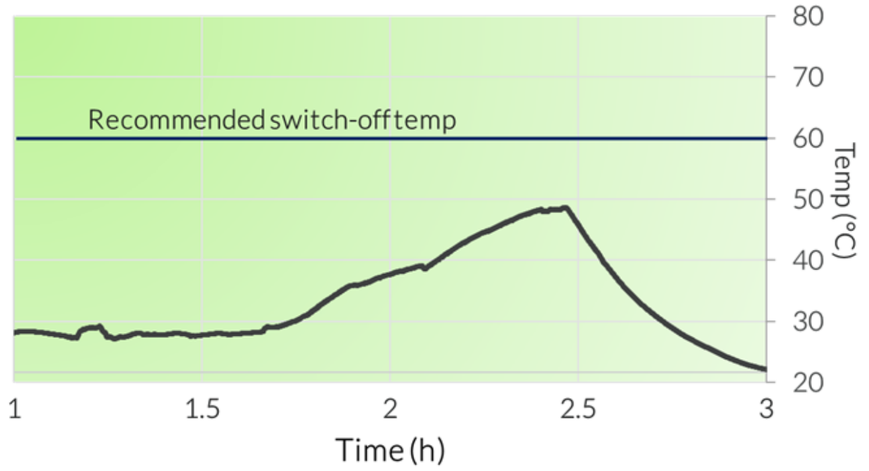
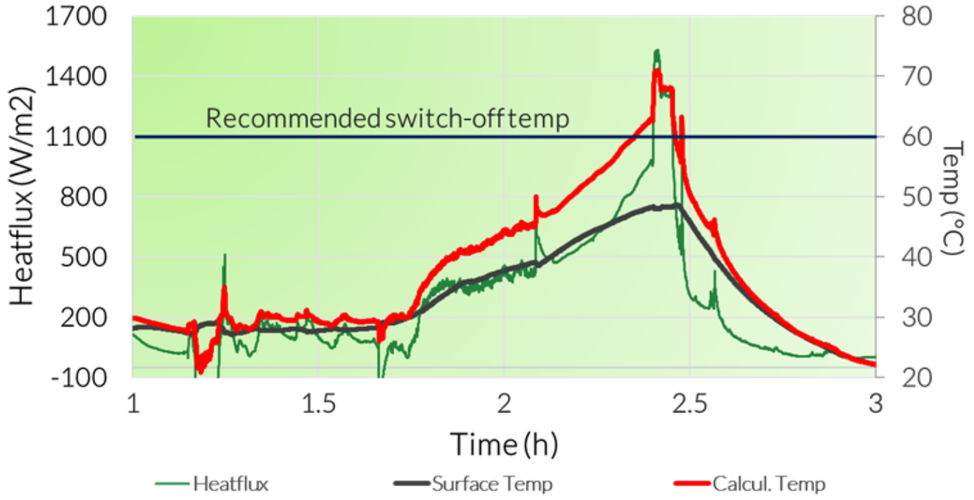
Heat Flux Sensors allow getting new insights about the inner performance of batteries/battery packs.





Surface temperature sensors only measures 48° C.

That might be ok for battery performance. However, this measurement might also be strongly influenced by the environment.

Our enhanced calculation using heat flux data reveals a new insights about the battery.

The heat flux sensor in combination with the surface temperature sensor reveals a critical inner battery temperature in the same device, exceeding 60° C.

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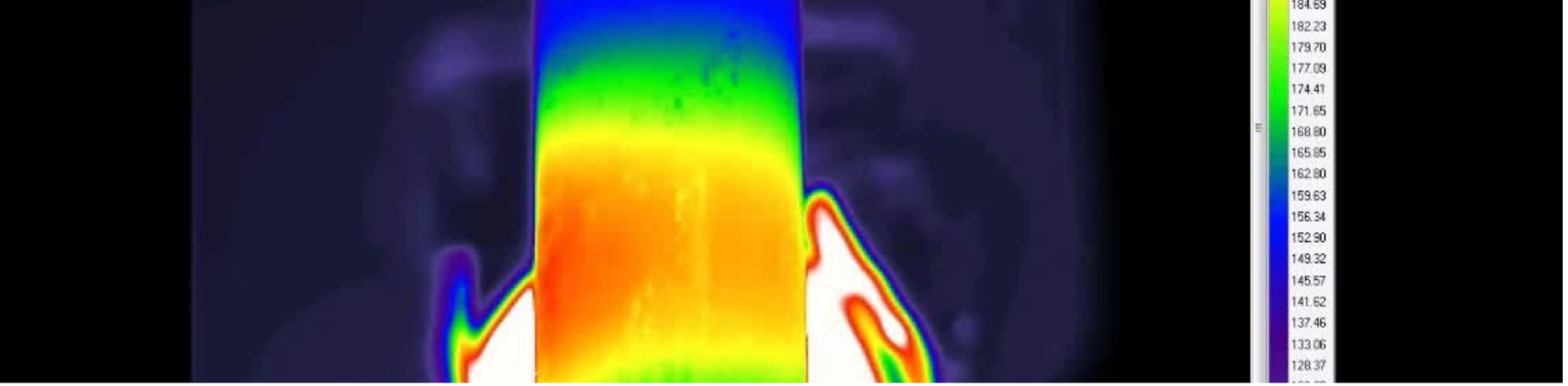


Battery thermal management

Controlled cooling/heating of the batteries helps to:

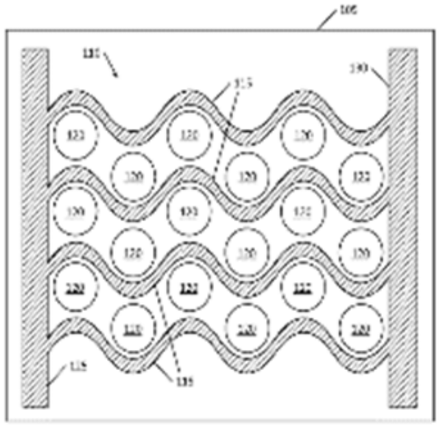
- Extend battery life
- Enable fast charging
- Avoid thermal runaway

Today, control is "only" based on temperature sensors

Problem: A temperature sensor measures a state and not the dynamics of the system. Therefore, it is not the right tool for systems control (it is slow, and overshoot)

Heat flux sensors react immediately to temperature changes larger than 100uK, resulting in:

- Much faster thermal control
- Improved thermal management



Reference: Patent on water cooled thermal management system from Tesla

greenTEG's technology allows you to measure the thermal dissipation even when water cooled

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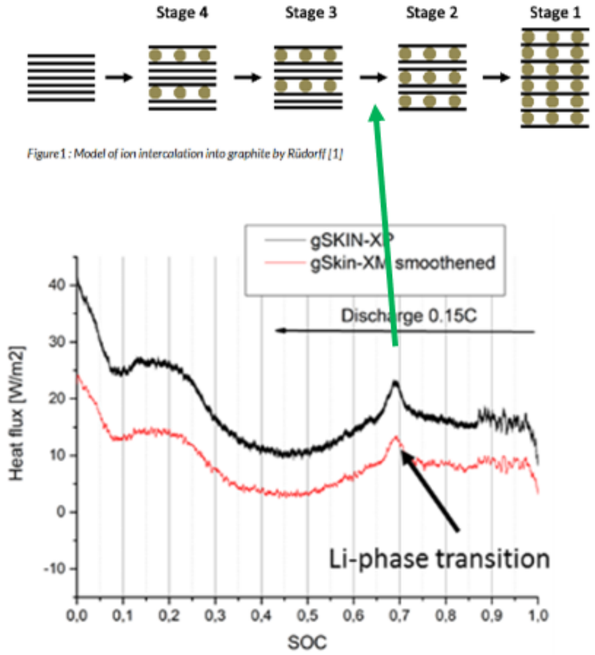
Battery status control and quality control

Click on the image above to watch an explanatory video.

With heat flux sensors, phase transitions of Li-ions in the electrodes can be detected during the normal charging and discharging of the battery

The sharpness, amplitude, and position of the peak is a clear indication of:

- Quality
- State of Health (SOH)
- Intracellular electrode disbalancing



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Main benefits of using heat flux sensors

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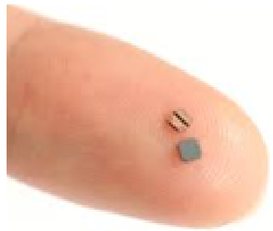


Regular calorimeter

Smaller

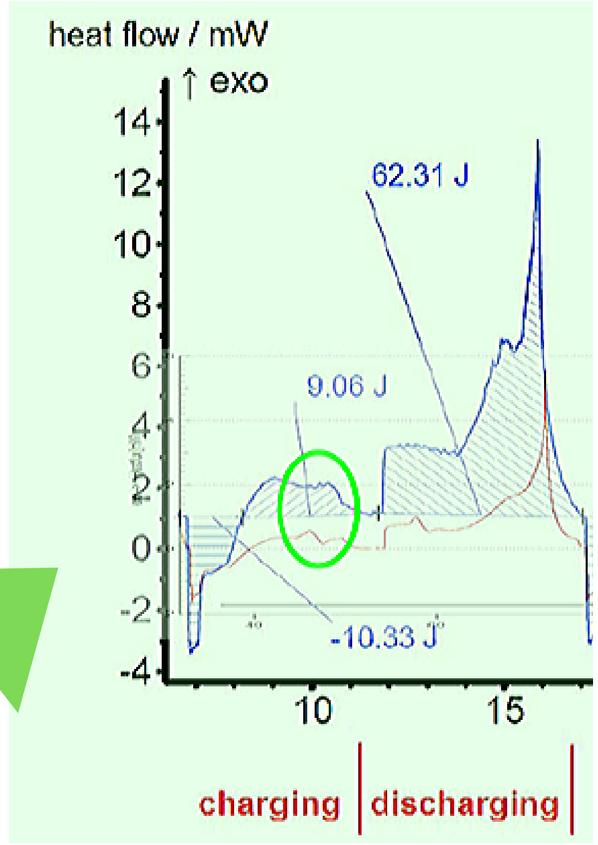
A gSKIN heat flux sensor is significantly smaller.

Cheaper

The price of a gSKIN heat flux sensor is only a fraction of the cost of a regular calorimeter.

Better perfomance

A heat flux sensor has improved feature resolution, a lower noise level, as well as no offset.



Battery calorimetry on a 45mA coin cell, cycling speed: 0.5 C;
Red: greenTEG HF sensor
Blue: Regular calorimeter
Results from EMPA (Swiss Federal Institute of material science and technology).

We are integration experts

Specifications:

- Sensor size: 2mm x 2mm x 0.4 mm.
- Sensitivity: > uV/W/m2.
- Required area: 2mm x 2mm x 0.5mm
- Standard SMD integration.
- Additional packaging for thermal heat path to the battery is required.

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Heat flux sensors for battery monitoring

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