

# Electrochemical impedance spectroscopy (T19)

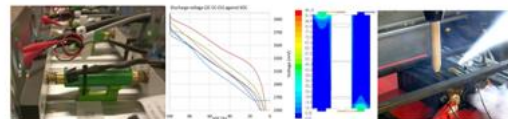
- Frequency response of battery cell to an electric signal (frequency sweep)
  - Voltage imposed, current measured (PEIS)
  - Current imposed, voltage measured (GEIS)
  - Intermediate approach (A-GEIS)
- The break-down of the total impedance of the cell permits to obtain information about contact and electrolyte resistance, charge transfer and interfacial resistances, transport limitations.



Draft White Paper

Test methods for improved battery cell understanding

Version 2.5



The research leading to these results has received funding from the European Community's H2020 Research Programme under grant agreement n° 659331/eCAIMAN, n°659373/SPiCY and n°659331/FiveVB.

R&D Status: Advanced



## Get more information on standards due to the existing literature

The finest literature is shown here to deepen your knowledge on battery standards, legislation and beyond.

Literature

### Defining test protocols for battery tests

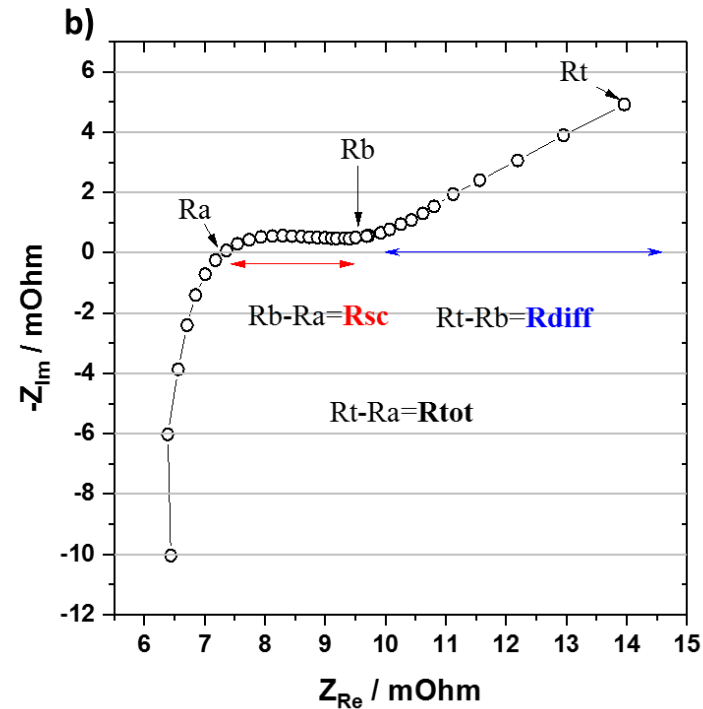
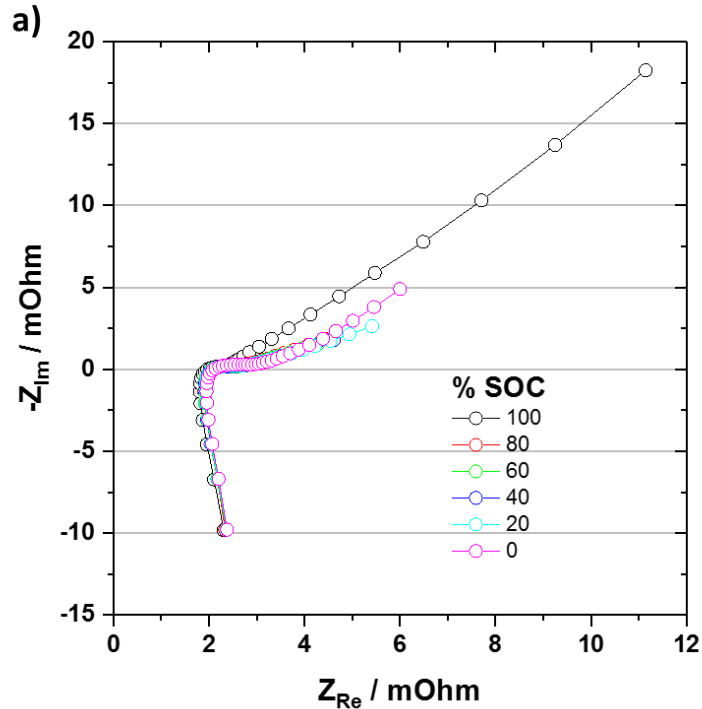
- [White Paper on Test methods for improved battery cell understanding](#)
  - Test methods on battery cell performance, ageing effects and safety aspects. Comparison with tests in standards are given. The methods have been optimised for using the results in modelling and application design. This document is an outcome of the projects Spicy, eCaiman and FiveVB.
- SPiCY Deliverable D5.1 'Test protocols definition for WP6 (including critical review of protocols)' (PDF)
  - Characterisation tests, ageing tests, abuse&reliability tests, analysis of EV logging data
- Mat4Bat D5.1 M31 'List of relevant regulations and standards' (PDF)
  - Regulation and directives
  - Characterisation tests (including materials), ageing tests, abuse&reliability tests
  - Labelling

### Review on test standards

- Mat4Bat D5.6 'Recommendations for the further development of regulations and standards' (PDF)
  - Confrontation of legislation and standards with the experience from the battery materials project
- Conclusions Pulling Science into Standards (P2SIS) Workshop 2016 'Driving Towards Decarbonisation of Transport: Safety, Performance, Second life and Recycling of Automotive Batteries for e-Vehicles'
  - Assessment on the standardisation and test needs for battery performance, safety, second life batteries and recycling.
  - The accompanying website
- A review of abuse testing standards and regulations for Li-ion batteries in (H)EVs
  - Scientific article with intention to compiling the relevant standards and regulations to identify shortcomings and areas for future improvement

# Electrochemical impedance spectroscopy

- Frequency response of battery cell to an electric signal (frequency sweep)
  - Influence of SOC
  - Influence of age (SOH)

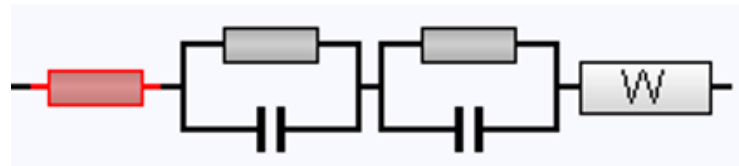
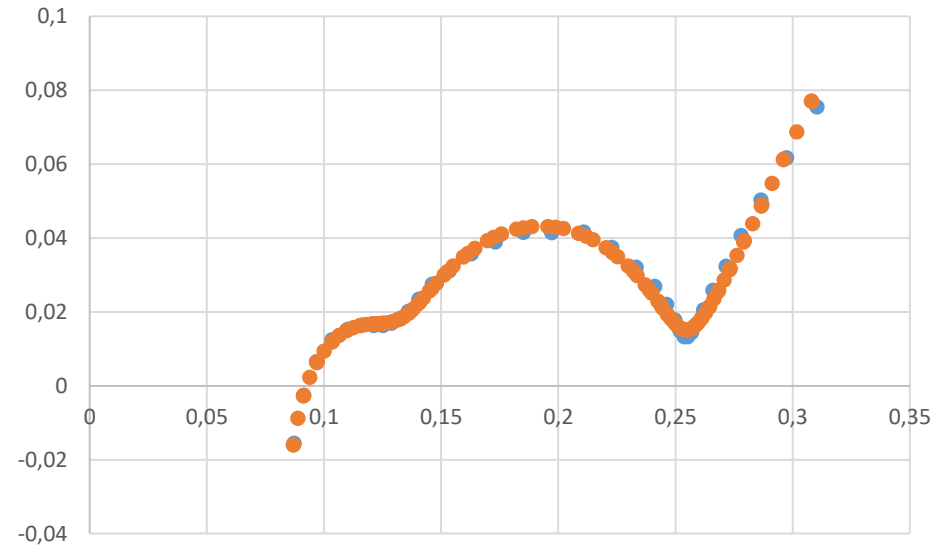
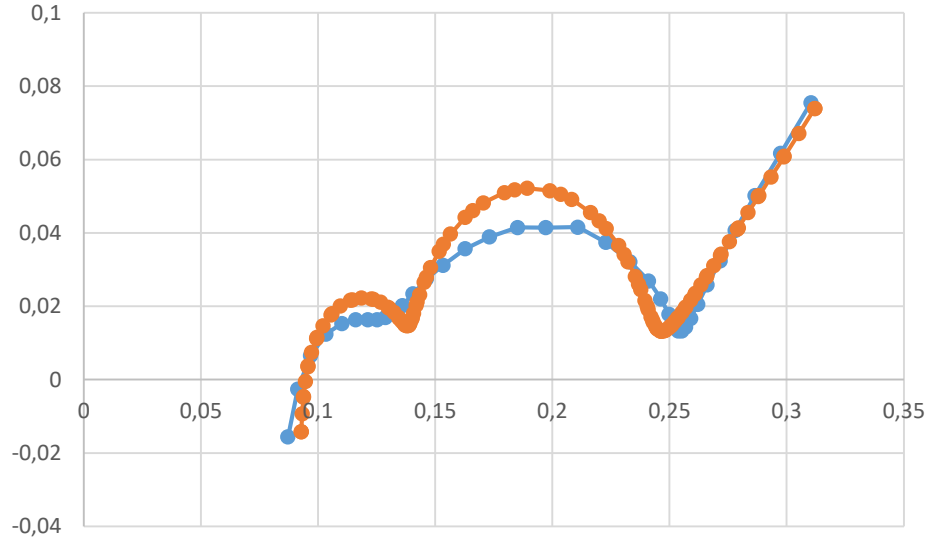


R&D Status: Advanced



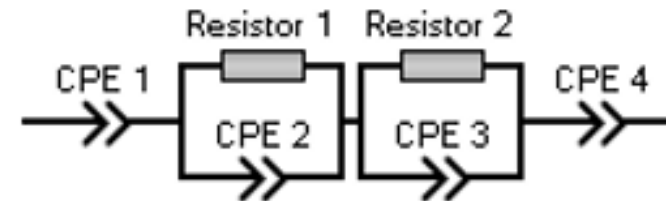
# Electrochemical impedance spectroscopy

- Frequency response of battery cell to an electric signal (frequency sweep)
  - Measurement versus fit model



Model:

$P - (R) (P) - (R) (P) - P$



SSR:

0,0003915



R&D Status: Advanced



# Electrochemical impedance spectroscopy

What can we characterize : cells

Experimental time: 1 day or longer

Advantage: a way to observe material properties just by the cell potential excitation.

Ageing behaviour can be derived.  
It becomes a method to estimate SOH.

Drawback: Response quite dependent on cell type and certainly on cell size.

R&D Status: Advanced

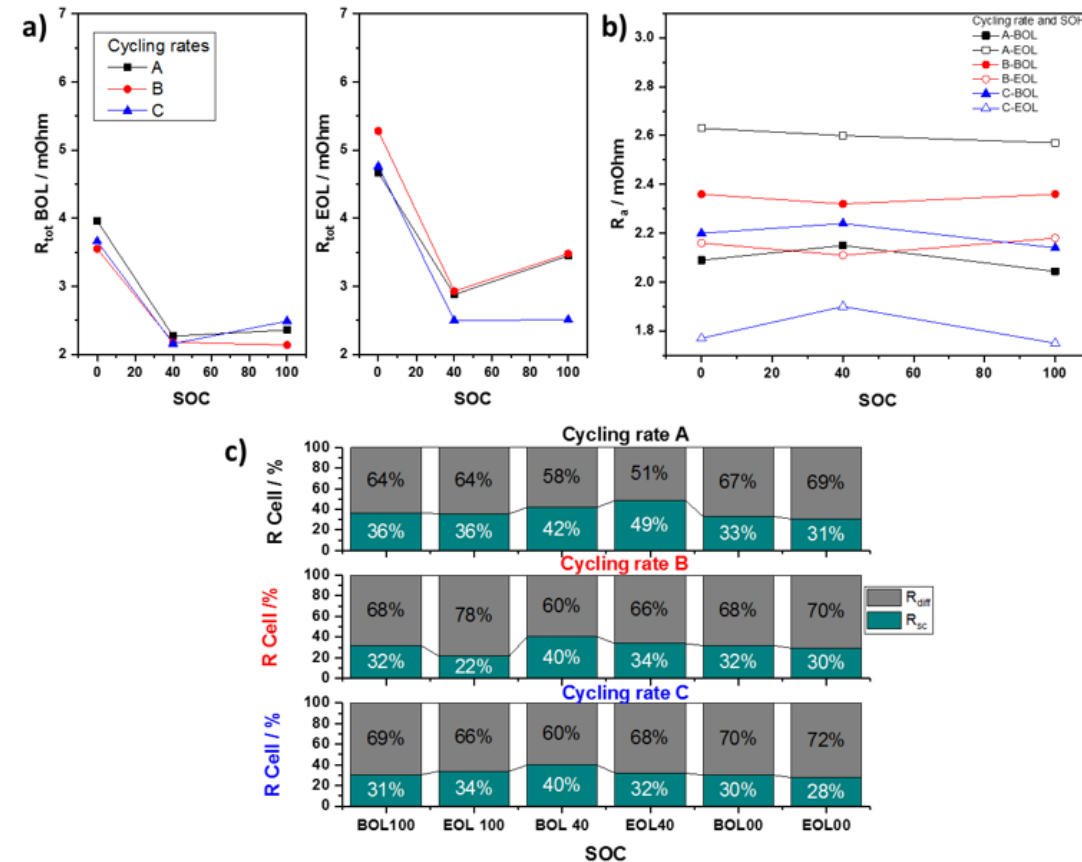


Figure 22: Example of qualitative analysis results. The cells were aged at different cycling rates. BOL and EOL express the SOH while the number the SOC at which the EIS spectra was measured.