EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g02**
Version: 1.0

Title: Metrology of Li-ion battery cells for electromobility applications

Abstract

Electrochemical impedance spectroscopy (EIS) is a promising method for the characterisation of Li-ion battery cells in automotive applications. However, this method often produces inconsistent and ambiguous data and a coherent measurement framework based on metrological principles is needed to eliminate these deficiencies and to substantiate results. These improvements to EIS test protocols, models and data interpretation will underpin advances in battery cell performance and cycle life, fostering innovation in electromobility and thereby significantly reducing greenhouse gas emissions and air pollution in European urban areas.

Keywords

Electrochemical impedance spectroscopy, Li-ion battery cells, electromobility

Background to the Metrological Challenges

A significant increase in electric vehicle production and sales is a cornerstone of European policy in order to reduce air pollution in urban areas, decrease the emission of greenhouse gases and effectively mitigate climate change. The European commission states in a policy framework for climate and energy in the period from 2020 to 2030: “The focus of policy development should be …, further development and deployment of electric vehicles …” [1], which is in line with the 2011 White paper, stating “The gradual phasing out of ‘conventionally-fuelled’ vehicles from the urban environment is a major contribution to significant reduction of oil dependence, greenhouse gas emissions and local air and noise pollution.” [2]. However, sales of electric vehicles are unfortunately still lagging behind political expectations. High initial costs and early battery aging are some of the biggest concerns of car buyers. Hence, innovative research and technological development that support the improvement of battery cell performance and the reduction of its costs are urgently needed in order to achieve the challenging political goals.

Li-ion battery cells will remain the battery technology of choice for electric propulsion systems for the foreseeable future but rapid and reliable diagnostic tools have yet to be established. Electrochemical impedance spectroscopy (EIS) is the most promising candidate to meet this challenge, since it is non-destructive, purely electrical, relatively fast and easy to use and sensitive to the internal processes of a battery cell. Current EIS measurement procedures to quantify the state of Li-ion battery cells are time consuming, impractical, inaccurate, gives poor insight into internal cell processes and the method is extremely sensitive to the definition of measurement conditions. As a consequence, even though EIS of Li-ion battery cells are widely used in laboratories, in test centres and production, its potential is hardly exploited. Moreover, no attempts have been made at all to standardise and validate EIS measurement procedures and parameters derived from EIS results as a means to assess optimisation efforts in cell design and production. A coherent measurement framework is needed.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement and characterisation of Li-ion battery cells by electrochemical impedance spectroscopy (EIS).

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The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

The specific objectives are

1. To develop and characterise low impedance reference standards covering resistance and reactance values relevant for high energy Li-ion battery cells (low mΩ-range), including development of calibration concepts and quantification of measurement uncertainties.
2. To assess EIS, under various measurement conditions, such as cell chemistry, cell capacity, state of charge (SoC), state of health (SoH) and temperature, to achieve measurement traceability and a measurement uncertainty of 1 % for measured impedances or derived quantities.
3. To establish and validate EIS as a method to quantify the optimisation process of Li-Ion battery cell performance in research and production taking into account a range of battery cells based on emerging materials and reference materials.
4. To improve the confidence in EIS measurement through correlation of physical, chemical and electrochemical processes with changes in the measured impedance spectra of Li-ion cells as well as through the correlation of electrical measurement results with in-situ and operando analytical techniques.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories), standards developing organisations (CENELEC) and end users (automotive industry).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the automotive sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] *Communication from the commission to the European parliament, the council and the European economic and social committee and the committee of the regions.* A policy framework for climate and energy in the period from 2020 to 2030 /* COM/2014/015 final, available at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0015

[2] *White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system /* COM/2011/0144 final*, available at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0144