# Wednesday, 5 July - Morning

## Plenary

Room: Cap-Ferret

*Chaired by: M. Orazem*

08:30 to 09:30

**Jianbo Zhang** (Dept. of Automotive Engineering, Beijing, China)

Application and Development of Electrochemical Impedance Spectroscopy (EIS) in Electrochemical Power Sources

## Batteries and fuel cells

Room: Cap-Ferret

*Chaired by: F. la Mantia*

09:30 to 10:10 Keynote

**Antonio Bertei** (Department of Civil and Industrial Engineering, University of Pisa, Pisa, Italy)

Physically-based Modelling to Unveil the Complex Interplay between Electrode Microstructure and Impedance Response

10:10 to 10:40

Coffee Break

10:40 to 11:00

**Armelle Ringuede** (IRCP / CNRS, Chimie Paristech, PSL University, Paris, France), Michel Cassir, André Grishin

A thorough analysis of transport mechanisms in molten carbonate/solid oxide composites as hybrid fuel cells electrolyte

11:00 to 11:20

**Pavle Boškoski** (Department of Systems and Control, Josef Stefan Institute, Ljubljana, Slovenia), Boštjan Dolenc, Dani Juricic, Gjorgji Nusev

Statistical Analysis of Impedance Data

# Physically-based Modelling to Unveil the Complex Interplay between Electrode Microstructure and Impedance Response

Antonio Bertei

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Solid oxide fuel cells (SOFCs) are promising systems which produce heat and power from the direct electrochemical conversion of a fuel, such as hydrogen, at high temperature. The cell performance and durability, which are typically assessed by using electrochemical impedance spectroscopy (EIS), are known to depend strongly on the microstructure of the porous electrodes. However, the complex interplay between electrode microstructure and EIS response is not well understood: very often spectra interpretation relies on phenomenological equivalent circuits and on empirical evaluations, thus making spectra deconvolution and the assessment of microstructure-performance correlation quite inaccurate.
In this work, we describe how the use of physically-based models, based on the mechanistic description of electrochemical phenomena occurring within the electrode microstructure, provide an effective strategy to quantitatively assess the interplay between electrode microstructure and EIS response. Taking advantage of tomographic techniques, which allow for the three-dimensional reconstruction of the electrode microstructure, we show how the microstructure-performance correlation can be accurately described and predicted in a wide range of conditions [1,2]. Then, we show how modelling and EIS can be integrated to infer kinetic information [3] and to elucidate the degradation mechanisms which undermine the stability of SOFC electrodes [4], revealing that paradigms commonly accepted for charge-transfer phenomena in porous electrodes should be revisited [5]. Finally, we report how inhomogeneous microstructural properties may affect the EIS response of a porous electrode, providing ad-hoc modelling tools [6] to help researchers deconvolve real impedance spectra with more awareness.

References

[1] Bertei et al., Validation of a physically-based solid oxide fuel cell anode model combining 3D tomography and impedance spectroscopy, Int. J. Hydrogen Energy 41 (2016) 22381-22393

[2] Bertei et al., Physically-based deconvolution of impedance spectra: Interpretation, fitting and validation of a numerical model for lanthanum strontium cobalt ferrite-based solid oxide fuel cells, Electrochim. Acta 208 (2016) 129-141

[3] Bertei et al., Understanding the electrochemical behaviour of LSM-based SOFC cathodes. Part II – Mechanistic modelling and physically-based interpretation, Solid State Ionics 303 (2017) 181-190

[4] Bertei et al., The fractal nature of the three-phase boundary: A heuristic approach to the degradation of nanostructured solid oxide fuel cell anodes, Nano Energy 38 (2017) 526-536

[5] Bertei et al., A perspective on the role of the three-phase boundary in solid oxide fuel cell electrodes, Bulg. Chem. Comm. 50 (2018) 31-38

[6] Cooper et al., Simulated impedance of diffusion in porous media, Electrochim. Acta 251 (2017) 681-689.