MS37 Advances in Structure determination of new materials by multi-technique approach including imaging techniques

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X-ray nano-analysis for energy-related materials at ESRF

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Abstract

Nowadays, the energy related materials are key actors in our energetical and ecological transition towards more sustainability. As a result, high-performance electrochemical devices, such as fuel cells and batteries, have rapidly spread worldwide for energy conversion and storage, respectively. Both systems are made of advanced materials, which can be multi-layered, poly-phased including various chemistries based on either low and/or light elements and complex multi-scaled microstructures. In order to develop efficient, durable and reliable devices, a deep understanding of the degradation processes occurring at the nano-scale is required within those structures [1-3].

In this context, X-ray nano-characterization provides unique opportunities. More especially, ultimate state-of-the-art synchrotron X-ray techniques offer an exclusive combination of spatial and temporal resolution. This presentation will focus on the capabilities of the nano-analysis beamline ID16B at the ESRF [4]. The beamline offers a multi-modal approach allowing for the characterization of heterogeneous materials in a non-destructive way using a combination of several powerful nano-scale techniques such as X-ray fluorescence (XRF), X-ray absorption spectroscopy (XANES), X-ray diffraction (XRD), and 3D phase contrast imaging (nano-CT). Each technique will be detailed along different case studies focused on Solid Oxide Cells (SOCs) and Li-ion battery degradation. First, new insights into chemical diffusion and formation of secondary phases at the interface of active layers will be illustrated using a multi-technique approach. Then, 3D morphological information obtained thanks to in situ nano-CT along a battery cycle will be depicted. Finally, the new opportunities for materials science investigation opened by the EBS upgrade at the ID16B nano-analysis beamline will be presented.

References

[1] A. Léon, A. Micero, B. Ludwig, A. Brisse, Effect of scaling-up on the performance and degradation of long-term operated electrolyte supported solid oxide cell, stack and module in electrolysis mode, Journal of Power Sources 510 (2021)230346

[2] A. Brisse, J. Schefold, A. Léon, High-temperature steam electrolysis, Chapter 7 in Hydrogen production by water electrolysis edited by T. Smolinka & J. Garche (2021)

[3] X. Han, L. Lu, Y. Zheng, X. Feng, Z. Li, J. Lia, M. Ouyang, A review on the key issues of the lithium ion battery degradation among the whole life cycle, eTransportation, 1, 1000005 (2019).

[4] Martínez-Criado G., Villanova J., Tucoulou R., et al., ID16B: A hard X-ray nanoprobe beamline at the ESRF for nano-analysis, J. Synchr. Radiat., 23, 344-352 (2015).