PhD 2018-2021 LRCS - CIRIMAT

Development of thick binder free electrodes by Spark Plasma Sintering for Li-ion batteries

Laboratories and people involved:

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Key words: Thick & binder-free electrodes, SPS technique, templating, Li-ion battery, tomography

Context of the study:

Improving the performance of Li-ion batteries goes through a significant increase in volume and surface densities of energy. The progress made both at the level of electrode materials and electrode architectures has led to improvements in terms of battery power in recent decades. However, still today, even the best batteries (eg for laptops) have a small amount of active material (approximately 51% by weight for cells with high energy density), the rest being divided between the current collectors 21%, packaging 13%, electrolyte 6.5%, binders and additives 8.5%.

Attempts to increase the thickness of the electrodes and their energy density while keeping the architectures of conventional electrodes have encountered many problems mainly because of limitations in terms of electronic or ionic conduction and of charge transfer at the interfaces, significantly limiting cycling regimes.

The topic of this PhD is to develop new solutions to achieve efficient thick electrodes through innovative processes. The electrode prepared will be characterized by various techniques to determine the microstructure, porosity and physical properties of the samples and will be tested in Li-ion batteries.

This PhD is included in the French Network on Electrochemical Storage of Energy (RS2E) and the fellow will have access to all characterization techniques and will be integrated in the network.

The proof of concept is published in the following article: R. Elango, A. Demortière, V. De Andrade, M. Morcrette, V. Seznec, Adv. Energy Mat., 2018, 1703031, DOI: 10.1002/aenm.201703031

Objectives and plan of work:

This work will imply some of the following tasks:

- Choice of the porogen/solvent agent with respect of the selected active material
- Synthesis and optimization of the microstructure of the porogen agent
- Optimization of the composite electrode formulation
- Optimization of the liquid electrolyte with respect to the pore. Optimization of the sintering parameters
- Ionogel/electrolyte impregnation
- 'Upscaling' study, i.e thickness, size of the final electrode
- Electrochemical studies (galvano, eis, power)
- Improvement of the mechanical properties

Materials will be prepared at LRCS. SPS experiments, electrochemical characterizations, tomography analysis will be performed at LRCS and/or CIRIMAT.

The candidate must hold a master in chemistry, electrochemistry, materials science or chemical engineering / electrochemistry. Ideally, he/she has knowledge in the field of batteries, and is familiar with various characterization techniques (electron microscopy, measurements of specific surfaces, XRD, electrochemistry).

Bibliography

- R. Elango, A. Demortière, V. De Andrade, M. Morcrette, V. Seznec, Adv. Energy Mat., 2018, 1703031, DOI: 10.1002/aenm.201703031
- J. S. Sander, R. M. Erb, L. Li, A. Gurijala, Y.-M. Chiang, *Nat. Energy* 2016, *1*, 16099.
- A. Aboulaich, R. Bouchet, G. Delaizir, V. Seznec, L. Tortet, M. Morcrette, P. Rozier, J.M. Tarascon, V. Viallet, M. Dolle, Adv. Energy Mater. 1 (2011) 179-183.
- G. Delaizir, V. Viallet, A. Aboulaich, R. Bouchet, L. Tortet, V. Seznec, M. Morcrette, J.-M. Tarascon, P. Rozier, M. Dollé, Adv. Funct. Mater. 22 (2012) 2140-2147