

Neutron depth profiling, present and future applications in Lithium ion batteries

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In 2009 Whitney et al.[1] described a new technique for the study of lithium ion batteries, Neutron Depth profiling. The technique allows to measure lithium concentrations, as function of depth, quantitatively and directly, while cycling[2]. In our field where reliable in operando techniques are scarce the technique was quickly adopted by a number of research groups in order to study problems such as degradation[3, 4] and rate limiting mechanisms[5].

In the future the technique will become even more powerful as with the development of high capacity anodes and cathodes the intensity will go up whereas at same time the stopping power is reduced. This opens a new window of opportunities as more lithium means increased statistics, while a lower stopping power extends the depth of view. In our group we combine these developments with a state of the art micro mesh gas filled detector[6] or time projection chamber and for first time demonstrate full 3dimensional mapping of the lithium concentration, again in-operando and at ambient pressures. The poster will show state of the art experiments, insights gained in the past year and concludes with an outlook towards applying the technique in 3 dimensions.

References:

1. Whitney, S., et al., *Neutron Depth Profiling Applications to Lithium-Ion Cell Research*. Journal of the Electrochemical Society, 2009. **156**(11): p. A886-A890.
2. Oudenhoven, J.F.M., et al., *In Situ Neutron Depth Profiling: A Powerful Method to Probe Lithium Transport in Micro-Batteries*. Advanced Materials, 2011. **23**(35): p. 4103-+.
3. Wang, J., et al., *Profiling lithium distribution in Sn anode for lithium-ion batteries with neutrons*. Journal of Radioanalytical and Nuclear Chemistry, 2014. **301**(1): p. 277-284.
4. Nagpure, S.C., et al., *Neutron depth profiling technique for studying aging in Li-ion batteries*. Electrochimica Acta, 2011. **56**(13): p. 4735-4743.
5. Zhang, X., et al., *Direct Observation of Li-Ion Transport in Electrodes under Nonequilibrium Conditions Using Neutron Depth Profiling*. Advanced Energy Materials, 2015. **5**(15).
6. Aarts, A.A., et al. *Discharge Protection and Ageing of Micromegas Pixel Detectors*. in *2006 IEEE Nuclear Science Symposium Conference Record*. 2006.