Electrolyte distribution and discharge time – a combined study of X-ray tomography and electrical measurements of a commercially available energy storage device

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In recent years X-ray tomography has been successfully used to study Lithium and Alkaline batteries [1-5]. In this paper, we demonstrate the high value of 3D imaging with X-rays for investigation of an energy storage device.
A commercial available Lithium-Ion-Capacitor (Li-Cap) consisting of an anode similar to an anode used in ordinary Lithium-Ion-batteries is cycled to 80 % of the initial capacity.

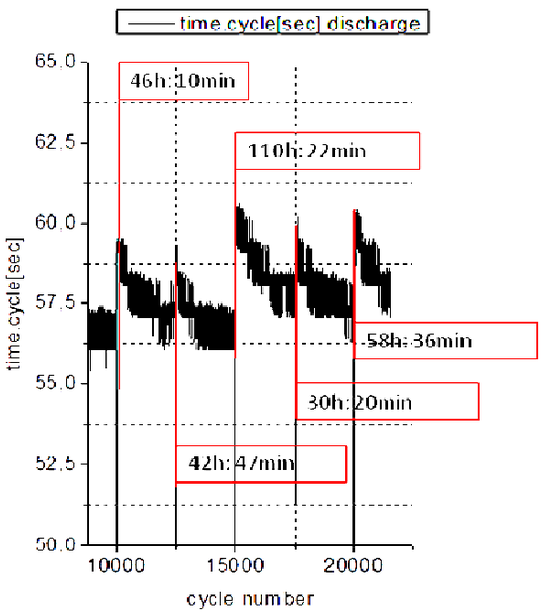

Fig. 1 shows the decrease of the discharge time during the cycling. At the state of 10000 cycles there is a significant increase in discharge time of about 5 % to 60 seconds after a non-cycling period of almost two days. This relaxations effect can repeated at 15000 cycles with an extended non-cycling period of 4.5 days. And again, at 20000 cycles the same effect occurs.

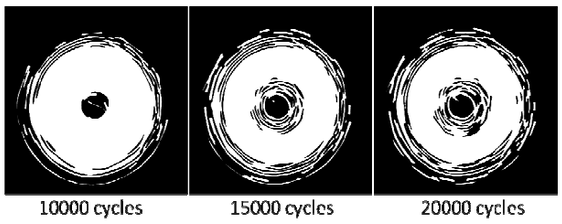

Fig. 2 shows the tomographic inspections of the bottom area of the Li-Cap as binary slices. The pristine Li-Cap has an equal distribution of electrolyte (shown in white) and gas (shown in black). At 10000 cycles there is an increase of the electrolyte area (about 66 %) and after a non-cycling period at 15000 cycles this area decreases to about 61 %. At 20000 cycles after an extended non-cycling period this value decreases to about 59 %.

The Li-Cap was investigated by X-ray tomography in certain steps. This research work is focused on the different relaxation effects of the Li-Cap after different periods of non-cycling. We have found a direct correlation between the distribution of the electrolyte and the electrical properties.
References:

[1] C. Hoch, H. Schier, Ch. Kallfass, Ch. Tötzke, A. Hilger, I. Manke, In-situ X-ray radiography studies on a LiPF6-free electrolyte system for high-voltage lithium ion capacitors, Micro & Nano Letters 7, 3, p. 262-264 (2012)
[2] Ch. Kallfaß, C. Hoch, A. Hilger, I. Manke
Short-circuit and overcharge behaviour of some lithium ion batteries, IEEE proceedings, International Multi-Conference on Systems, Signals and Devices 2012, ISBN/ISSN 978-1-4673-1591-3/12, (2012)
[3] J. Banhart, Advanced Tomographic Methods in Materials Research, Oxford University Press (2008)
ISBN 978-0-19-921324-5
[4] I. Manke, J. Banhart, A. Haibel, A. Rack, N. Kardjilov, A. Hilger, S. Zabler, A. Melzer, H. Riesemeier
In situ investigation of the discharge of alkaline Zn-MnO2 batteries with synchrotron X-Ray and neutron tomography, Applied Physics Letters 90(21), 214102 - 3 pages (2007)
[5] A. Haibel, I. Manke, A. Melzer, and J. Banhart,
In Situ Microtomographic Monitoring of Discharging, Processes in Alkaline Cells, Journal of the Electrochemical Society 157, 4, A387-A391 (2010)