Introduction of Charging Curves Analysis Technologies for Diagnosis and Control of Lithium ion Batteries

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Lithium ion batteries have a higher energy density and longer life performance and their costs have been decreasing rapidly [1]. Consequently, lithium ion batteries have been applied in wide variety of devices, such as smartphones, electric vehicles and stationary energy storage. The batteries installed in such devices will operate from 2 years to 20 years and their performances would deteriorate by degradation of the batteries. In addition, the internal state of degraded batteries would be quite different depending on the operating condition [2] and the degradation could sometimes cause safety problems [3]. Therefore, it would be necessary to evaluate the degradation of installed batteries for stable operation and maintenance.

To settle these problems, we have developed a charging curve analysis (CCA) for diagnosis of lithium ion batteries in practical usage. CCA estimates the internal state of the batteries, such as cathode capacity, anode capacity, SOC shifting and internal resistance, using regression analysis based on open circuit potential curves of active materials. Fig.1 shows the basic structure of CCA algorithm.

The advantage of CCA is that it is suitable for installed batteries in devices, because CCA algorithm is not easily influenced by the noise of charging data comparing with a kind of dVdQ analysis and EIS technologies.

We applied the CCA method to evaluate commercially available LFP/Graphite lithium ion batteries during aging tests. Conditions of aging tests were 3C cycling tests at 25deg.C and 60deg.C floating tests at SOC 100 % charge. The Charge curves for CCA estimation were obtained at 0.1C rate. The estimated results showed remarkable agreement with measured internal sate of degraded cells by decomposition analysis. Fig.2 shows the change of internal state of the test cells during cycling and storage tests, estimated by using CCA. The difference of degradation mechanism between cycling and storage was clearly indicated by results of CCA estimation.

From the experimental results, we concluded that CCA would makes it possible to evaluate the health of batteries through their internal state from only the charging curve data. And application of CCA would enhance the stability for operation of installed batteries in devices.

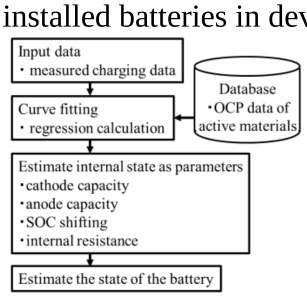

Fig.1 Schematic figure of CCA algorithm

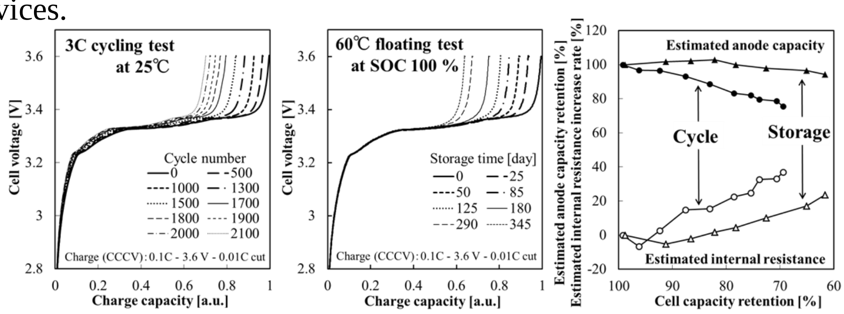

Fig.2 Charge curves and results of CCA estimation

References:

[1] A. A. Asif et al., Batteries 3 (2017) 17-31.

[2] Y. Kobayashi et al., J. Electrochem. Soc. 160 (2013) A1181-A1186.

[3] M. Fleischhammer et al., J. Power Sources. 274 (2015) 432-439.