Operando Analysis of Thermal Runaway in Lithium Ion Battery during Nail-Penetration Test using X-ray Inspection System

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Safety of the battery, especially lithium ion battery, LIB, is most important for the use of energy storage devices. LIBs designed for commercial use must pass safety standards, and safety tests, for example electrical test, environmental tests, and mechanical tests, are carried out to maintain these standards [1]. This type of safety test only checks whether an LIB is safe, but an analysis of the test results is not carried out from an academic viewpoint [2]. In this study, direct observation of the internal state of a battery cell was investigated, and thermal runaway of LIB during nail-penetration test was investigated.

An industrial micro X-ray CT scanner (TOSCANER-32252 μhd-HS (Type C), Toshiba IT & Control Systems Corporation) was used to record X-ray transmission moving images of the electrode behavior during the nail-penetration test. This X-ray scanner was added to Nail-penetration testing system, and direct operando measurement system of nail-penetration test was developed. The LIB with 430 mAh with measurement window was prepared for this nail penetration test. These measurements were carried out as a collaborative test of the National Laboratory for Advanced Energy Storage Technologies (NLAB), Global Center for Evaluation Technology (GCET), and National institute of Technology and Evaluation (NITE).

Fig. 1 shows X-ray transmission images of the LIB during the nail-penetration test. From Fig.1A, the structure of the anode and cathode were clearly observed in the layered LIB structure. During nail-penetration test, smoke generation outside the battery and ballooning of the pouch was observed at around 7 s and around 20 s. From Fig.1B, changing layered structure in the pouch was directly observed, and increase of the distance of the layers was observed with smoke generation. Since the results of a conventional nail-penetration test are indicated only by smoke generation, fire, or explosion, this new system allows electrode changes in the pouch during thermal runaway to be observed. This system is expected to lead to great developments in the safety of LIBs.

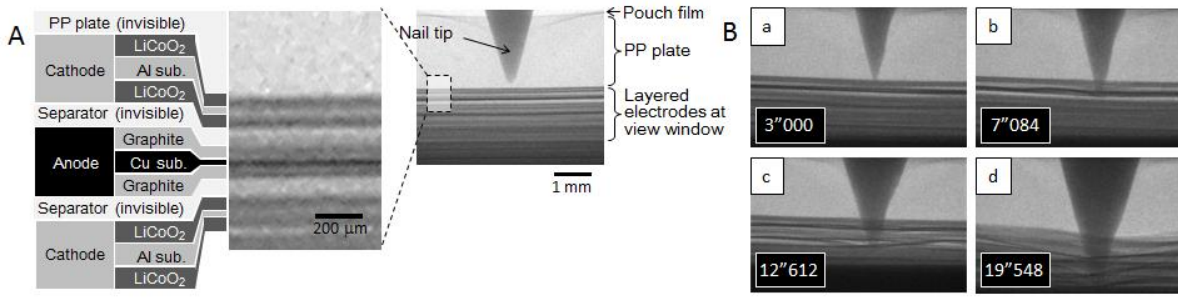

Fig. 1. X-ray transmission images of laminated-type LIB during the nail penetration test. A:before nail-penetration test, B: during nail-penetration test.

References:

[1] JIS C8714:2007, 2007-11-12., IEC 62133 Ed. 2.0:2012 (b), 2012-12-06., JIS C 8715-2: 2012, 2012-07-20.

[2] M. Takahashi, K. Maeda, JARI Research Journal, 2015.9, (2015) 1-4.