

Experimental Evaluation of Thermal Runaway and Thermal Propagation Behavior in Lithium-Plated Cells Using Laser Irradiation

Kenichiroh Koshika¹⁾ Hideki Tsuruga²⁾ Tomokazu Morita³⁾ Keizoh Honda²⁾

1) National Traffic Safety and Environment Laboratory

42-27, Jindaiji-higashimachi 7-chome, Chofu, Tokyo, 182-0012, Japan (E-mail: koshika@ntsel.go.jp)

2) Japan Electrical Safety & Environment Technology Laboratories

3) TOSHIBA CORPORATION

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The National Traffic Safety and Environment Laboratory (NTSEL) has confirmed through laboratory studies that lithium plating in lithium-ion batteries reduces thermal stability and may contribute to fire incidents and damage escalation in electric vehicles. In our previous work, thermal propagation behavior associated with lithium-plated cells was preliminarily reported [1]. However, thermal runaway characteristics of individual lithium-plated cells and the mechanism of thermal propagation acceleration have not been sufficiently evaluated.

In this paper, thermal runaway and thermal propagation behaviors of lithium-plated lithium-ion cells were experimentally investigated using a laser irradiation method. Lithium plating was induced through repeated charge-discharge cycling under low-temperature conditions. The presence of metallic lithium was confirmed by negative electrode observation and solid-state ⁷Li-NMR analysis.

Thermal runaway tests were conducted on individual cells using laser irradiation, and thermal stability was evaluated based on the input energy required to initiate thermal runaway. Thermal propagation tests were also conducted using paired-cell configurations consisting of a trigger cell and an adjacent cell. The influence of lithium plating on thermal propagation behavior was evaluated by comparing fresh cells and lithium-plated cells.

The following results were also obtained:

- Metallic lithium on the negative electrode of the cycled cell under low temperature was confirmed by solid-state ⁷Li-NMR analysis.
- Lithium-plated cells underwent thermal runaway with an input energy of 1156 J, corresponding to only 13.6% of the energy required for fresh cells (8475 J), indicating significantly reduced thermal stability.
- In thermal propagation tests, the propagation time from the trigger cell to the adjacent cell was approximately 1 s for a fresh–lithium-plated configuration (Fig. 1), compared with approximately 79 s for a fresh–fresh configuration.
- These results experimentally demonstrated that lithium plating significantly degrades thermal stability and accelerates thermal propagation behavior in lithium-ion batteries.

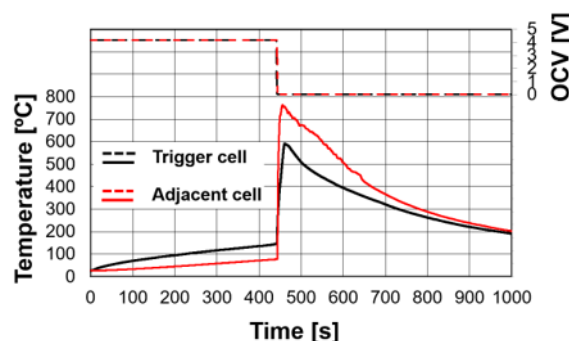


Fig. 1 OCV (open circuit voltage) and temperature profiles for a thermal propagation test with a fresh–lithium-plated configuration.

Reference

- (1) Koshika, K., Tsuruga, H., Honda, K., “Demonstrating the Influence of Lithium Plating on Thermal Propagation and Lithium Plating Occurring in Mechanically Constrained Cells” Proceedings JSAE Congress (Spring), 20265046.