Demonstrating the influence of lithium plating on thermal propagation and lithium plating occurring in mechanically constrained cells

Kenichiroh Koshika [1)] **Hideki Tsuruga** [2)] **Tomokazu Morita** [3)] **<u>Keizoh Honda</u>** [2)]

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 Laboratory
3) TOSHIBA CORPORATION

KEY WORDS: **EV and HV systems, Lithium ion battery, Electrical safety (A3)**

The National Traffic Safety and Environment Laboratory (NTSEL) has conducted research on EV safety, including the mechanisms of thermal runaway, evaluation methods for thermal propagation, and non-destructive safety diagnosis. Our previous report [1] examined lithium plating as a key factor that increases the risk of thermal runaway (Fig. 1), and demonstrated that charging curve analysis (CCA)—a type of nondestructive estimation method—can detect early indications of this risk. Building on that work, this paper presents two laboratory sutdies that further investigate lithium plating: (i) its influence on thermal propagation, and (ii) its occurrence in mechanically constrained cells.

Two laboratory-level experiments were conducted to clarify the influence of lithium plating on thermal propagation and to confirm that mechanical constraint during cycling gives rise to lithium plating. In the thermal-propagation experiment, thermal runaway propagated to an adjacent lithium-plated cell more rapidly than to a fresh cell, indicating reduced thermal stability associated with lithium plating. In the mechanical-constraint experiment, cells under constraint exhibited earlier capacity degradation than unconstrained cells and showed lithium plating on the negative electrode after cycling.

The following results were also obtained:

- The influence of lithium-plated cells on thermal propagation was demonstrated, and the occurrence of lithium plating in cells cycling under mechanical constraint was verified.
- Thermal propagation to a lithium-plated adjacent cell occurred more rapidly than to a fresh cell, indicating that reduced thermal stability associated with lithium plating can accelerate its spread in multi-cell configurations. Therefore, reduced thermal stability during the in-use phase needs to be accounted for in EV-battery safety design.
- Lithium plating in cells cycled under mechanical constraint is considered to the resulting internal inhomogeneities (Fig. 2). Metallic lithium deposits emerged in regions influenced by the mechanical constraint from the early stage of low-temperature cycling, and thermal stability decreased relative to a fresh cell; the cycle-induced internal inhomogeneities due to the constraint was considered to have contributed to the onset of lithium plating. Cycle-induced internal inhomogeneities, when envisioned for EVs or swappable battery systems, can arise from local case indentation caused by impacts (e.g., vehicle collisions or drops); under such circumstances, lithium plating may occur as a result of the internal inhomogeneities by the indentation.

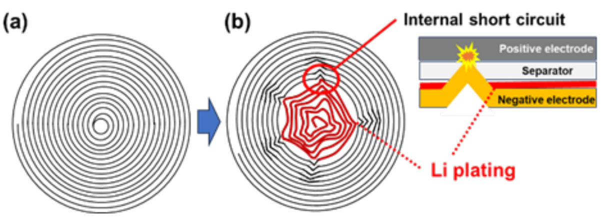

Fig. 1 Schematic image of internal short circuit induced by lithium plating in an electrode coil (a) initial state, (b) after deformation due to lithium plating.

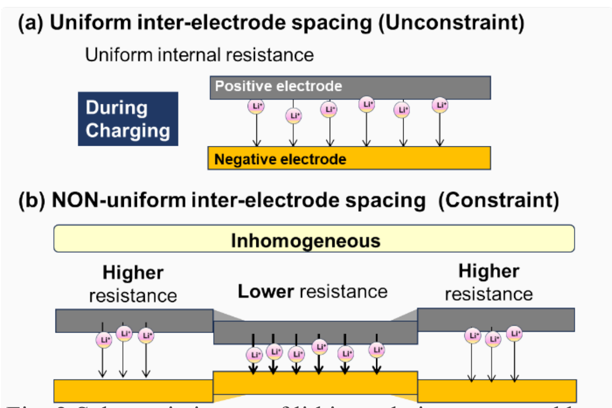

Fig. 2 Schematic image of lithium plating promoted by internal inhomogeneities.

Reference

(1) Koshika, K., Tsuruga, H., Morita, M., Honda, K., “Pre-feasibility Study on Detecting Increased Risk of Thermal Runaway for Batteries Using the Charging Curve Analysis as a Non-Destructive Diagnostic Method” Transactions of Society of Automotive Engineers of Japan, Volume 55 Issue 5 Pages 853-858, 2024.