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Press Release

April 27, 2020

Institute for Materials Research, Tohoku University
Sumitomo Chemical, Co., Ltd.

Tohoku University and Sumitomo Chemical Reveal a New Mechanism for Preventing Deterioration of Aluminum Anode during Cyclic Battery Reactions

Summary

- Discovered that the use of high purity aluminum foil can successfully control the huge volume expansion/contraction of high capacity aluminum anodes during charge/discharge processes, and clarified its mechanism.
- Determined that high purity aluminum foil can be an "integrated anode", which can replace two components of the conventional graphite anode, i.e., a layered structure of carbon material (that accommodates lithium ions) and copper foil (that functions as a substrate to collect current) as it plays the roles of both components.
- Contributed to higher performance and significant simplification of the battery manufacturing process.

Abstract

Research Assistant Professor Hongyi Li and Professor Tetsu Ichitsubo *et al.* at Institute for Materials Research, Tohoku University and researchers at Sumitomo Chemical have jointly undertaken the research and development of novel anodes for higher capacity of lithium-ion rechargeable batteries since April 2019. This joint research group has successfully elucidated a new mechanism for circumventing the huge volume strain during charge/discharge battery reactions with the use of a high purity aluminum foil alone as anode.

Lithium-ion rechargeable batteries consist of four components: a cathode, an anode, an electrolyte, and a separator film. Lithium ions move between the cathode and anode when the battery is charged or discharged; when charging, the anode takes in the lithium ions released by the cathode, and the reverse when discharging. Carbon-based materials are currently the mainstream for anodes. However, the use of silicon or metals such as tin and aluminum, has been considered as promising anode materials for high energy-density batteries because these materials can store three to ten times more lithium ions than the same weight carbon-based materials. Despite the higher capacity for absorbing more lithium ions, the application of metal anodes has been deadlocked because their huge volume changes (two to four times) can destroy the anode's structure.

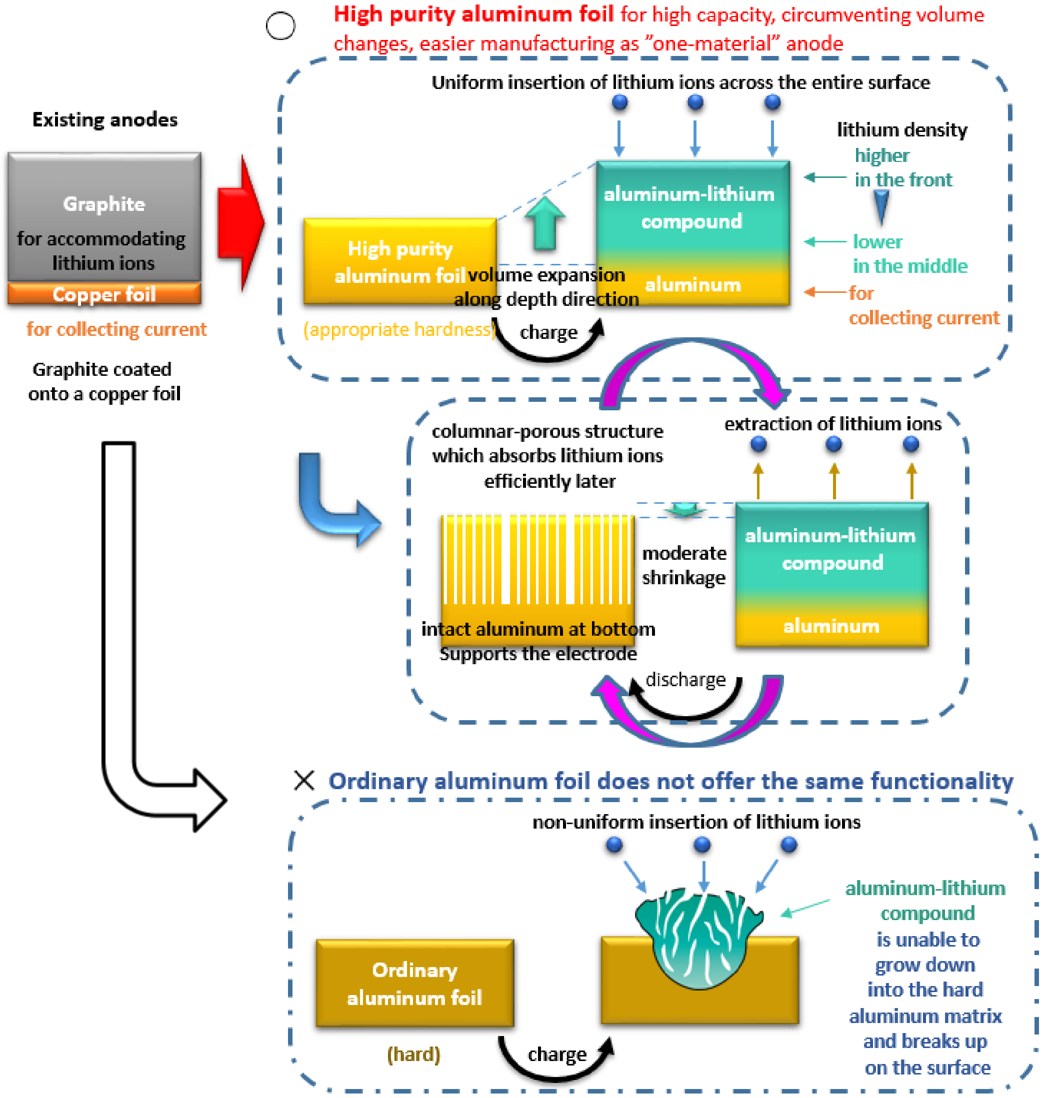
The joint research group has discovered that optimizing the hardness of high purity aluminum foils can control volume changes, thereby finding a solution to this long-standing issue. This discovery was made possible by integrating the excellent materials science capabilities of the Institute for Materials Research, Tohoku University and the excellent technologies that Sumitomo Chemical has cultivated to date through its high purity aluminum business. As the integrated aluminum anode can dramatically streamline the manufacturing process of lithium-ion batteries, the two organizations expect that this will reduce impacts on the environment while allowing for the creation of higher capacity, lighter weight, and lower priced lithium-ion rechargeable batteries. These research results can also be applied to next generation solid-state batteries, dual-ion batteries, etc.

Institute for Materials Research, Tohoku University and Sumitomo Chemical will continue their joint research efforts toward practical implementation of the integrated aluminum anode and contribute to the development of a sustainable society.

Technical details

- In the charging process, optimization of the hardness of high purity aluminum foil enables uniform insertion of lithium ions across the entire foil surface.
- After the formation of uniform layer of aluminum-lithium compound (AlLi) across the entire front surface, a concentration gradient is formed between the surface of the foil and the interior, due to the tolerance of off-stoichiometric composition in that intermetallic compound, even though the ratio is not one-to-one. This causes aluminum element within the foil to move toward the surface uniformly across the entire face, ensuring that expansion only occurs along the thickness dimension of the foil during charging (lithium insertion).
- In the discharging process, lithium ions are extracted from the side of the aluminum-lithium compound electrode foil that has expanded in the charging process due to the insertion of lithium ions. The remaining aluminum shrinks moderately to form a columnar-porous structure, which efficiently accommodates lithium ions again for the next charge process.
- The bottom of the aluminum foil remains intact, serving as a substitute for the copper foil of conventional graphite anodes, collecting current and maintaining a stable electrode structure. In other words, the high purity aluminum foil alone can be a two-in-one integrated anode.

Schematic illustration of the mechanism that the joint team has elucidated



The research was published in *Nature Communications* (online version, April 13, 2020)
https://www.nature.com/articles/s41467-020-15452-0

Publication details

Journal: Nature Communications

Title: Circumventing Huge Volume Strain in Alloy Anodes of Lithium Batteries

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DOI: 10.1038/s41467-020-15452-0

Acknowledgements

This work is a joint research project contracted between the Institute for Materials Research at Tohoku University and Sumitomo Chemical Co. Ltd. This work is partly supported by Grant-in-Aid for Scientific Research (S) number 18H05249 and Grant-in-Aid for JSPS Research Fellow number 18J11696 commissioned by Japan Society for the Promotion of Science (JSPS).

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