Research and Development of All-Solid-State Lithium-ion Battery
− Low Cost Battery Preparation Approach using Carbon Anode Materials −

Background

Lithium-ion batteries used in mobile electronics contain flammable organic solvent in their electrolytes so that further safety management is required for the development of kWh scale stationary-type storage system. Although an all-solid-state lithium-ion battery using non-volatile solid polymer electrolyte (SPE) will be expected for improvement of safety and reduction of cost, the combination with carbon-based anode material, which is already used in the conventional liquid electrolyte, was believed to be difficult in the suitable combination. Therefore, there was no report about the combination of SPE with such carbon-based electrode until now.

Objectives

The study aims to determine application of the carbon-based (graphite) anode with low-cost production process and large-area preparation process for the development of all-solid-state lithium-ion battery.

Principal Results

All-solid-state lithium-ion battery, consisting of [LiFePO4 | SPE | Graphite], could be prepared by the overcoating of SPE on the conventional graphite electrode sheet. The detailed clarified results are listed below.

1. The preparation procedure of all-solid-state lithium-ion battery [Low-cost production]

The battery preparation process using the overcoating method (Fig. 1) required no liquid filling process and needed no high-cost separator. Furthermore, the process has the potential to produce the battery by one-line process, so it will be expected to reduce the preparation process.

2. Large area and stacking battery preparation in one exterior package [Large battery production]

A flat-type (active surface area: $104cm^2$) battery could be prepared using aluminum-laminated package by the vacuum treatment of the battery inside. The prepared battery could operate with the suitable reversible capacity which was estimated from its surface area (Fig. 2). Furthermore, the demonstrated series-connected battery in one exterior package suggested the possibility of compact and large battery development (Fig. 3).

3. Charge discharge cycle performance [Cycle life]

The prepared all-solid-state lithium-ion battery exhibited suitable initial properties (Fig. 4). Furthermore, the optimized graphite electrode showed excellent cycle performance of 75% capacity retention at the 250^{th} cycle, which suggested a quite good prospect for the development of long-life all-solid-state lithium-ion batteries.

Further Developments

Further optimization of battery design and process will be developed.

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Reference

Yo Kobayashi et al., 2008, “Research and development of all solid state lithium ion battery”, CRIEPI Report, Q07018 (in Japanese)

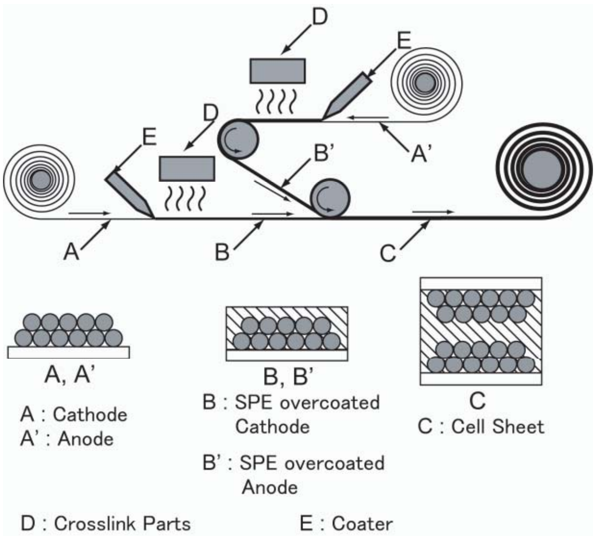

Fig.1 Proposed battery preparation process using overcoating method.

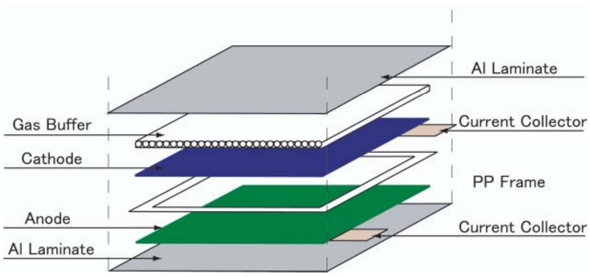

Fig.2 A schematic of a flat cell using vacuum gas buffer.

Fig.3 Operated 4-stack cell（13.69 V, 13×8cm flat-type. No additional pressure from outside）

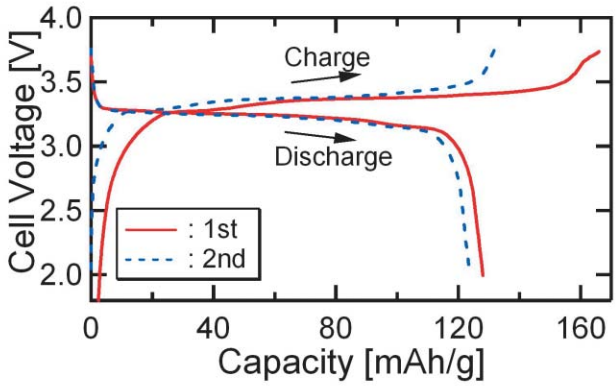

Fig.4 Charge / discharge voltage profiles of [LiFePO4 | SPE | Graphite] all-solid-state lithium-ion cell.

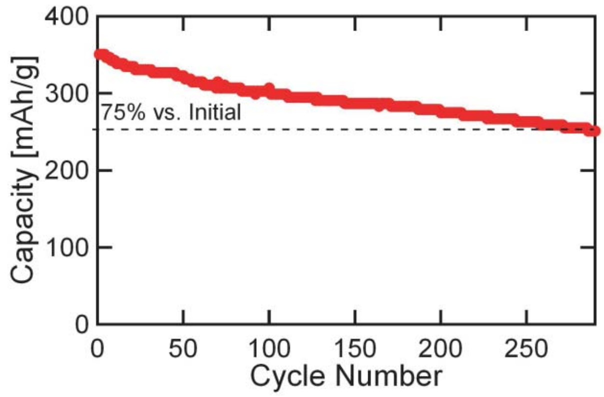

Fig.5 Cycle performance of [Graphite | SPE | Li] cell. 75% capacity was obtained at the 250th cycle.