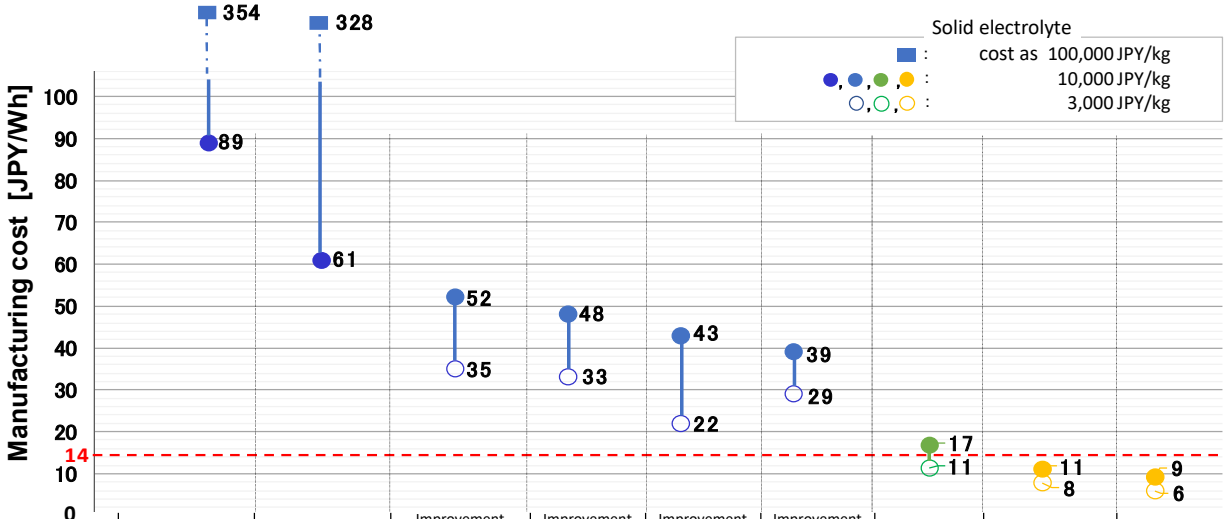
Secondary Battery System (Vol.8): Cost Evaluation and Technological Challenges of an All-solid-state Lithium-ion Battery

As the energy density of lithium-ion batteries (LIBs) has increased and the demand for safety has increased, attempts to use inorganic solid electrolytes have gained attention. In this proposal, a laminated all-solid-state LIB cell using a sulfide-based solid electrolyte was designed and the manufacturing cost was calculated. In addition, technological obstacles to reducing the manufacturing cost were discussed.

- The manufacturing cost of the all-solid-state LIB using solid electrolyte $75Li_2S$-$25P_2S_5$ was as follows : the cost of Current Model 2 was 61 to 328 JPY/Wh, the costs of Future Models 1 to 3 were 6 to 17 JPY/Wh (Figure 1). On the other hand, the cost of conventional LIBs (same battery size as Current Model 2) was 14 JPY/Wh.
- The assessment revealed that the manufacturing cost of the all-solid-state LIB is heavily influenced by (1) the price of the solid electrolyte, (2) the amount of solid electrolyte used, and (3) the manufacturing process needed to use sulfide-based solid electrolytes (high-pressure press, atmosphere control in the presence of solid electrolytes).



		Current model 1	Current model 2	Improvement proposal 1	Improvement proposal 2	Improvement proposal 3	Improvement proposal 4	Future model 1	Future model 2	Future model 3
Battery composition	Electrode active materials Material (positive/negative)	NCA / C_6	NCA / C_6	NCA / C_6				NCA / C_6	$Li_{1.2}Ti_{0.4}Mn_{0.4}O_2$ / Si	S-C/Li
	Capacity (positive/negative electrode) [mAh/g]	196 / 353	196 / 353	196 / 353				196 / 353	300 / 1,007	1,508 / 2,895
	Composition ratio of positive electrode compound (active material/solid electrolyte/other) [vol.%]	46/48/6	46/48/6	46/48/6	46/48/6	46/48/6	63/28/9	63/28/9	64/28/8	50/28/22
	Composition ratio of negative electrode compound (active material/solid electrolyte/other) [vol.%]	53/41/6	53/41/6	53/41/6	53/41/6	53/41/6	66/27/7	66/27/7	59/27/14	100/0/0
Battery performance	Energy Density by Weight [Wh/kg]	189	194	219	194	194	252	278	441	788
	Energy Density by Volume [Wh/L]	419	452	495	452	452	631	676	1,027	979
Manufacturing conditions	Cumulative yield of positive electrode active material standard [%].	64	64	64	88	64	64	88	88	88
	Price of solid electrolyte [JPY/kg].	10,000 - 100,000	10,000 - 100,000	3,000 - 10,000				3,000 - 10,000	3,000 - 10,000	3,000 - 10,000
Note	Differences from current model 2 (except for price of solid electrolyte) Note: NCA is an abbreviation for Li $(Ni_{0.85}Co_{0.12}Al_{0.03})O_2$	Battery size: small	—	Thickening of the electrode compound layer	Increased manufacturing yield	Increased manufacturing efficiency + easing of atmosphere controls	Reduction of content containing solid electrolytes	Combined with improvement proposal 1 to 4	Combination of substituting with high-capacity electrode material +improvement proposal 1 to 4	Combination of substituting with high-capacity electrode material + improvement proposal 1 to 4

Figure 1: Comparison of manufacturing costs for the all-solid-state LIBs used in the assessment

Future Challenges

In order to reduce manufacturing cost and increase the performance of all-solid-state LIBs to the level of the future model, it is important to find a solid electrolyte with the following features: (1) desirable physical properties (good lithium ion conductivity, chemical and electrochemical stability, and softness to form a good interface with low pressure pressing) (2) low-cost raw materials, (3) manufacturing process suitable for mass production.

https://www.jst.go.jp/lcs/pdf/fy2019-pp-12.pdf