



Title	Technologies of Lithium Ion Polymer Battery
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Citation	電気材料技術雑誌. 2005, 14(2), p. 143-148
Version Type	VoR
URL	https://hdl.handle.net/11094/76828
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Technologies of Lithium Ion Polymer Battery

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Lithium Ion Battery (LIB) has been known to the general public as power source with higher energy density, longer cycle life, larger capacity and smaller self-discharge than those of commercial rechargeable batteries (Ni-MH, Ni-Cd and so on) [1-2]. Therefore, lithium ion battery has been used widely in the 3C market such as Mobile phone, Camcorder and Laptop since 1990's. Specially, Lithium Ion Polymer Batteries (LIPB) are in spotlight in secondary battery market because it is very light but has higher energy density than LIB and then is using the main power for Electric Vehicle (EV) in recent.

Fig. 1 shows the technology tree of battery. LIPB is located in the top of battery technology and is at the cutting edge of secondary battery technology.

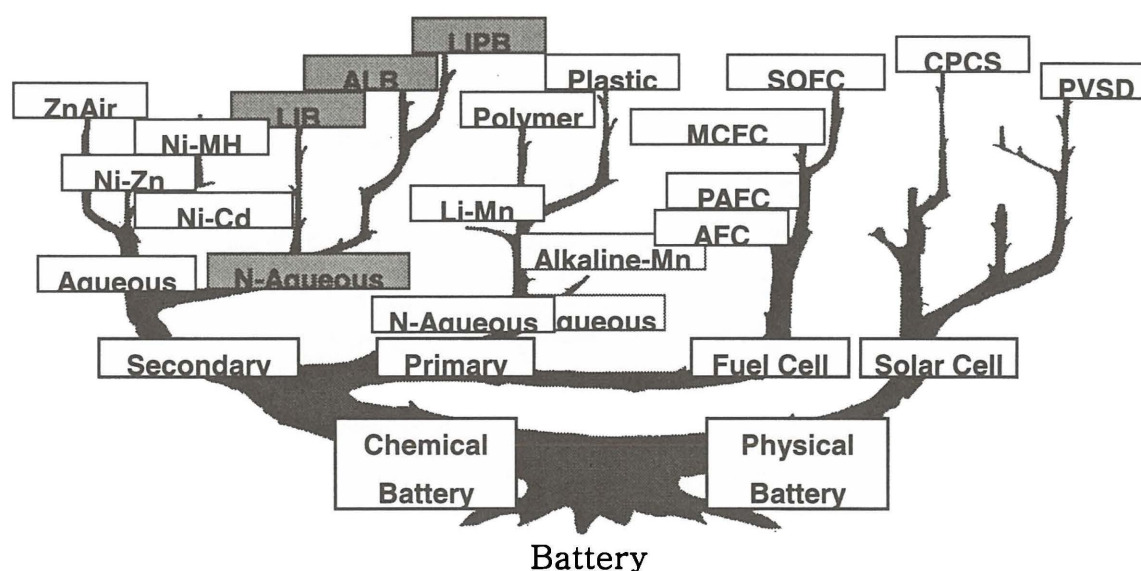


Fig. 1. Battery Technology Tree

Fig. 2 explains about energy density comparison of several secondary batteries. The vertical line represents gravimetric energy density which means to be able to make battery light. LIPB system is to be lighter than other battery system. The horizontal line represents energy density per volume which means to be able to make battery small. LIPB system is to be smaller than other battery system. It is reasonable for LIPB system to be selected as the most powerful source of the secondary battery system in the world.

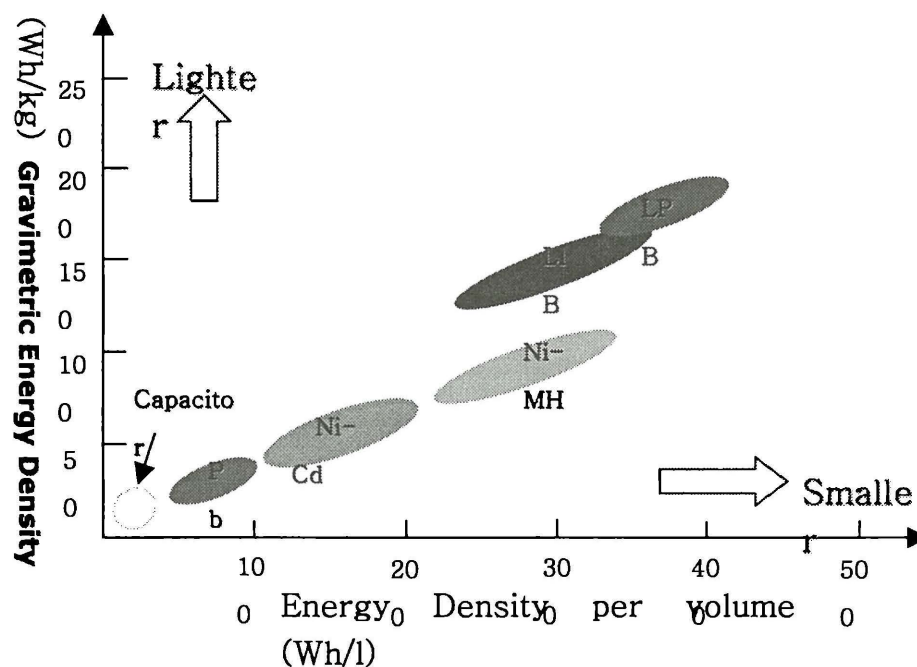


Fig. 2. Energy density comparison of various secondary batteries.

Reaction mechanism of Li secondary battery is very simple as shown at the Fig. 3. Li ion battery consists of a carbon anode and a cathode of Li metal compound (LiCoO_2). Li metal is not in the battery. That means the safety of lithium ion battery is a good theoretically if manufacturing default is not generated in. Li ion in the crystal structure of lithium cobalt oxide (LiCoO_2) is only moving to the Graphite layer during the discharge and then return to the cathode during the charging. We call this mechanism as the rocking chair or shuttlecock [3-5].

Li ion battery systems are divided into four parts according to the types of anode material or cathode material as shown at the Fig. 4. If liquid electrolyte and carbon anode is used, the system is defined as the lithium ion battery. Li Ion polymer battery system use carbon anode and polymer electrolyte.

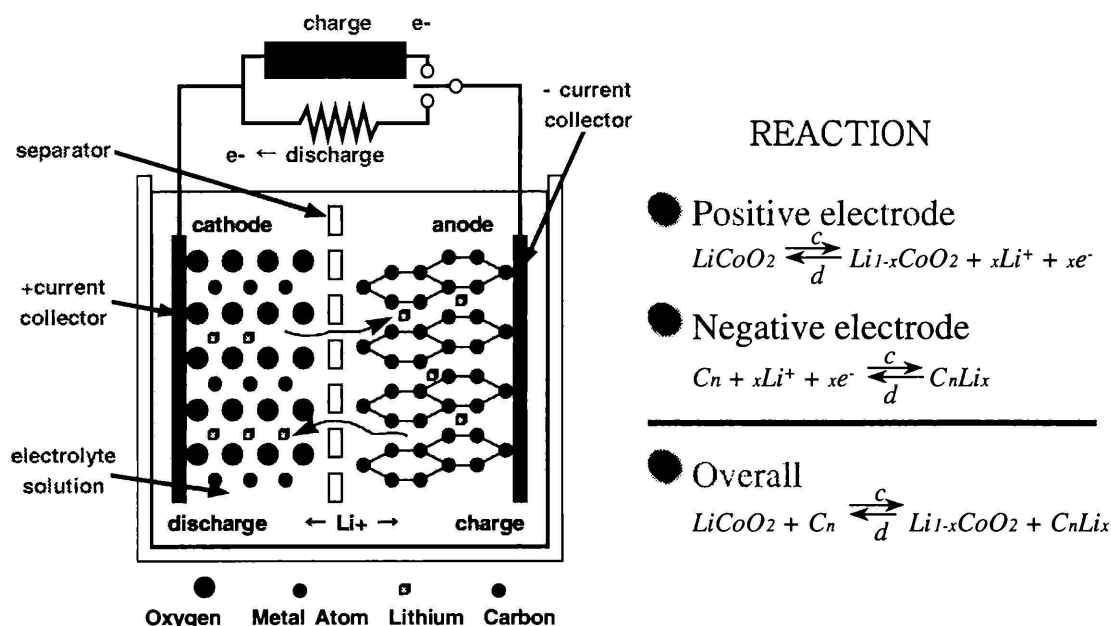


Fig. 3. Reaction mechanism of lithium ion battery.

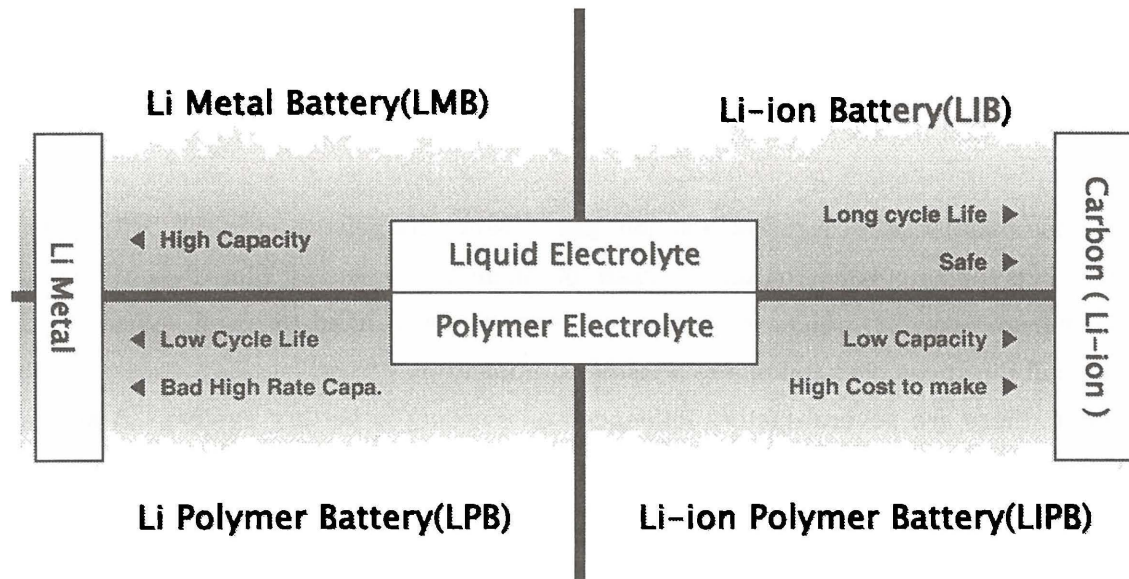


Fig. 4. Derivative systems of lithium ion battery.

Li Ion polymer battery has many advantages in aspects of battery performance, comparing with lithium ion battery. LIPB is able to be thinner, lighter, cheaper and more flexible design than LIB. Specially, a safety of LIPB is better than LIB so that LIPB system is apt to use power source of Electric Vehicle and is popular to the high power system to derive motor such as electric tools and R/C appliances.

However, It is necessary for us to solve swelling problem to apply LIPB to commercial electronic appliances. The swelling problem is to be main defect and affects on the change of cell thickness as shown at the Fig. 5.

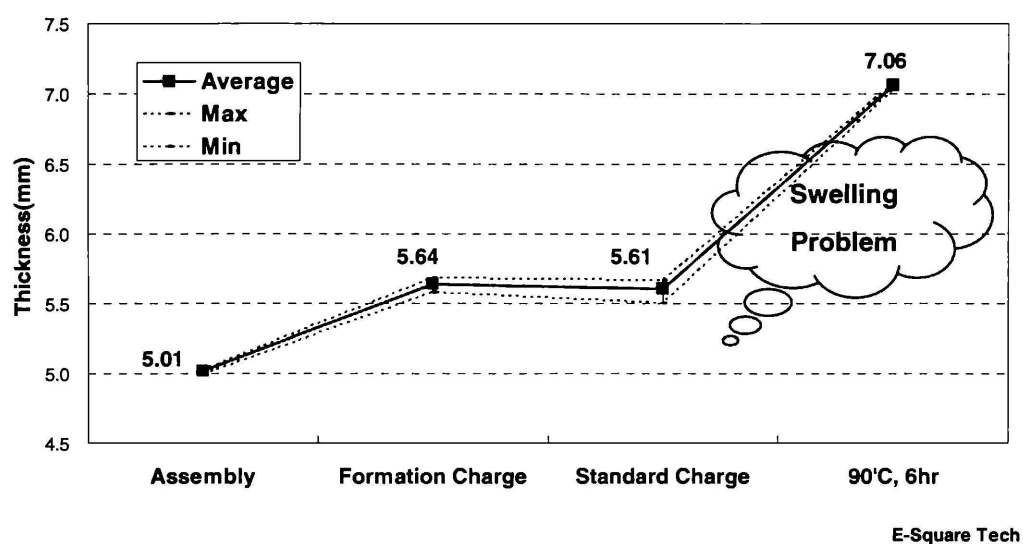


Fig. 5. Cell thickness variation of LPB on the storage test condition under 90°C.

When the battery starts a redox reaction, gas is generally generated in the battery, the exterior of the Li polymer battery is made of Aluminum laminated film (Pouch) instead of aluminum can like lithium ion battery. The pouch is inclined to swell easily and to make cell thickness changed due to weakness of material.

In facts, there are several factors influenced on swelling in battery system. A special solution which prevents gas from being generated in the battery is added additive material to electrolyte in the LIPB.

It has been paid close attention to search for functional electrolyte with additive material. Functional electrolyte is designed to generate a dense film called solid electrolyte interface (SEI) on the surface of carbon anode during the first charging process. We expect functional electrolyte to protect a continuous gas evolution for the cycle running. We calculated HOMO (highest occupied molecular orbital) and LUMO (lowest unoccupied molecular orbital) level of additive materials like as much as 150EA to select promising additive materials as shown at the Fig. 6.

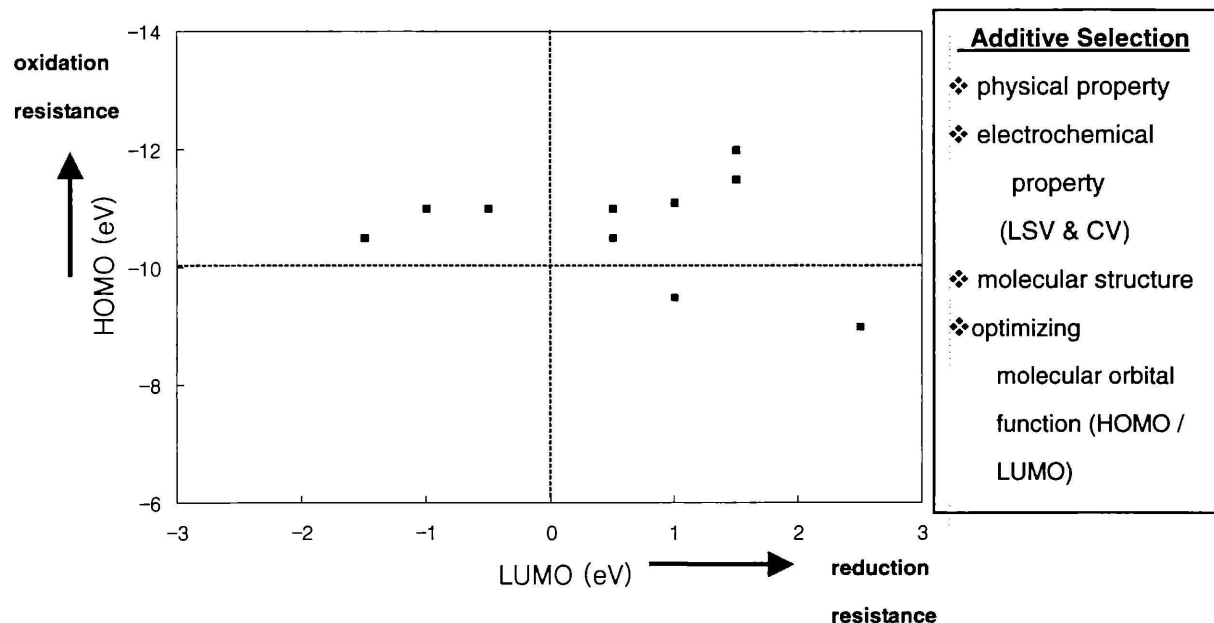


Fig. 6. An extent of redox reaction on HOMO and RUMO value.

Fig. 7 shows variation of cyclic voltammetric profiles between general electrolyte and functional electrolyte with additive material, SEI formation due to the decomposition of functional electrolyte is appearing at the lower voltage than one of general electrolyte. The research of quantitative and qualitative analysis on SEI film is now on progressing in our laboratory.

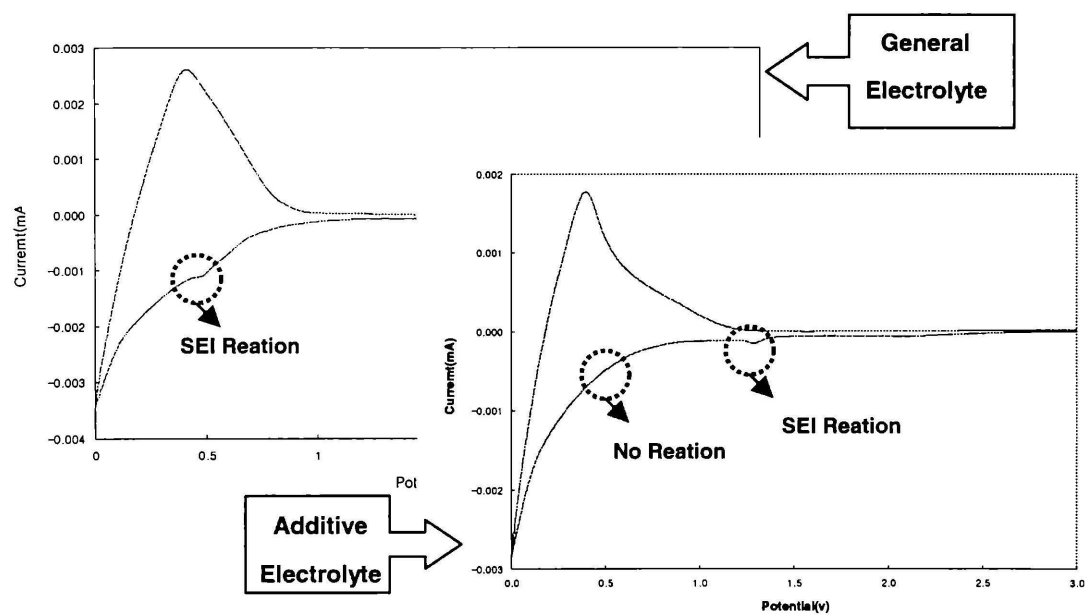


Fig. 7. Variation of cyclic voltammetric profiles between general E/L and additive E/L.

Fig. 8 shows the effect of functional electrolyte. Test condition of cell is designed to show clearly the change of cell thickness under 85°C. Functional electrolyte decreases effectively the cell thickness by 30% after 7 days, comparing with general electrolyte. Swelling in terms of the change of initial thickness is controlled by 3% in the functional electrolyte. SBACA (2-Sulfobenzoic acid cyclic anhydride) shows a good characteristic to control cell thickness as the additive material in electrolyte. SBACA is now in pending on international patent as the material of swelling restraint.

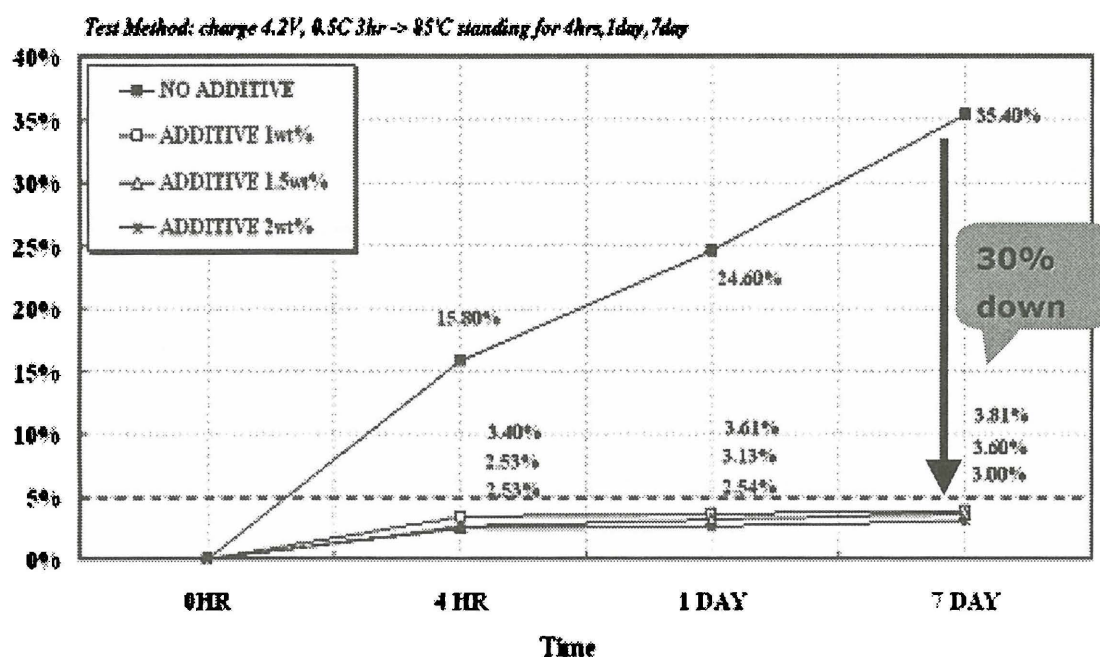


Fig. 8. Effect on swelling restraint under 85°C standing for 4hrs, 1day and 7days.

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