1. Small li-ion rechargeable batteries

1-1 Structure of small li-ion rechargeable batteries for use in devices where L and W dimensions are limited.

The table below provides an overview of the SLB.

Table 1–1. Product specifications

Category		Function
Product number		SLB03070LR35
Nominal capacity*1		0.35mAh
ESR@1kHz*2		Max. 12Ω
Voltage	Average operating voltage	2.4V
	Maximum charging voltage	2.8V
	Minimum discharge voltage	1.8V
Current	Maximum charging current	7mA
	Maximum discharging current	7mA
Temperature	Operational temperature range	–30°C to +60°C
	Storage temperature range	–30°C to +60°C

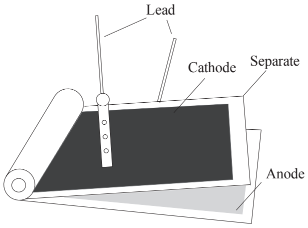
*1 Nominal capacity measurement direction

(1) Pre-discharging: Discharging at 1C (0.35mA) to the lower-limit voltage of 1.8V
(2) Charging: After charging at 1C (0.35mA) to the upper-limit voltage of 2.8V, constant-voltage charging* at 2.8V
*Constant-voltage charging occurs until nominal capacity x 5% (mA) is reached.
(3) Resting: 30 minutes
(4) Discharging: Discharging at 1C (0.35mA) to the lower-limit voltage of 1.8

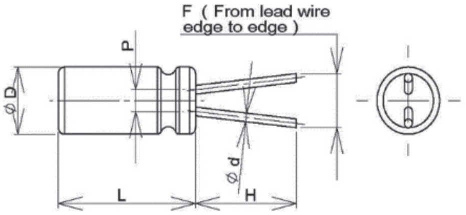
*2 ESR measurement direction:

(1) Pre-discharge: Discharging at 1C (0.35mA) to the lower- limit voltage of 1.8V
(2) Charging: After charging at 1C (0.35mA) to 2.4V, charging at rated capacity x 5% (mA) at 2.4V
(3) Measuring: AC impedance measurement used to check actual resistance at 1kHz

[Winding element]



[Product exterior]



[Product dimensions]

Size	φD0	L0	φd	P
φ3×7L	3.1±0.1	6.8+0.2/–0.1	0.40±0.05	1.0±0.3

Figure 1-1. Shape and dimensions of small li-ion rechargeable batteries

1-2 Materials in small li-ion rechargeable batteries

Small li-ion rechargeable batteries are manufactured by applying the electrode technology utilized in Toshiba Corporation's SCiB™ rechargeable batteries. The most distinctive feature in the design of our small li-ion rechargeable batteries is the use of lithium titanate ($Li_4Ti_5O_{12}$) rather than graphite as the anode active material. As is discussed in "2. Features of small li-ion rechargeable batteries", The selection of the optimal electrolyte and separator combined with the lithium titanate electrode is key to realizing the battery's superior functionality.

The cathode and anode reactions during charging and discharging of small li-ion rechargeable batteries is described below.

In electric double-layer capacitors, the electrode surface and ions in the electrolyte form an electric double layer that forms the energy storage mechanism. By comparison, small li-ion rechargeable batteries use an electrochemical storage mechanism that utilizes electrochemical reactions. Battery capacity is realized through the adsorption and release of lithium ions in the electrodes. Self-discharge is limited as a result.

Standard lithium-ion rechargeable batteries use electrolytes comprised of lithium salts dissolved in an organic solvent. The lithium ions in the electrolytes remain suspended in the organic solvent. When a designated voltage is applied, the lithium ions migrate, resulting in them becoming stacked within the anode.

On the surface of the anode's active material is a solid electrolyte interphase (SEI) coating—a compound in which electrolytes undergo reductive decomposition and possess high lithium conductivity. As Figure 1-2 shows, when the anode undergoes the electrochemical reaction, the disassociated lithium ions pass through the SEI coating and begin to stack up.

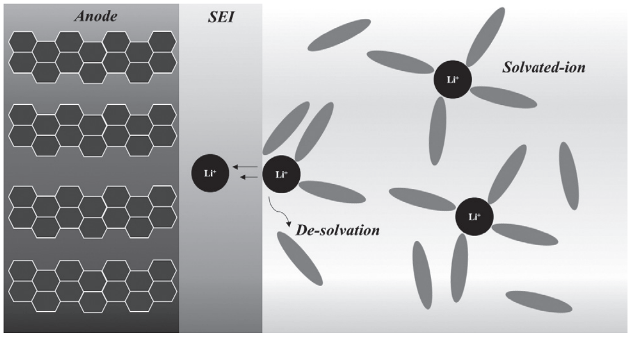


Figure 1-2. Reaction mechanism on the anode of lithium-ion rechargeable batteries

However, the passage of lithium ions through the SEI coating on the surface of the anode active material generates significant resistance, and that resistance becomes larger as SEI coatings grow thicker. In addition, lithium ions are consumed in the electrolyte when SEI coatings are formed. An effective way to form a thin SEI coating is to select anode materials that have a reaction potential higher than the electrolyte's decomposition rate.

Graphite is typically used as the anode material for standard lithium-ion rechargeable batteries. The potential for reaction with the lithium ions is extremely small, at 0.1V vs. Li/Li+, which is one reason for the decomposition of electrolytes, and the formation of thick SEI coatings., This results in higher levels of resistance. By contrast, using lithium titanate in the anodes the lithium ions reaction voltage is 1.55V vs. Li/Li+, Reactions at a higher potential result in the formation of a thin SEI coating that reduces electrolyte decomposition. The lower resistance means fewer lithium ions are consumed in the electrolyte, and superior life properties are acheived.

Optimizing the electrode, separator, and electrolyte results in superior high-temperature tolerance and cycle life performance. Using highly safe active materials results in superior product safety.