Electrochemical Characteristics of Li Plating Reaction on the Graphite Negative Electrode in Lithium-ion Batteries

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Recently, there is an increasing demand for quick charging that shortens the charging time of a lithium ion battery (LIB). However, it takes a lot of time to recharge the batteries, since the solid-state diffusion rate of lithium ions in the graphite is too low. Consequently, lithium is easily electroplated at the surface of the graphite when the very large currents are applied to the graphite. Also, lithium is electroplated in case of overcharging because lithium can no longer be stored inside the graphite. The plated lithium causes a failure of electrochemical performance due to an internal short circuit as well as resistance increase. Therefore, research on electroplating of graphite is necessary for the appropriate charging technique and quick charging performance.

In order to understand these electroplating behaviors, several electrochemical tests such as constant current charge and discharge test, GITT (galvanostatic intermittent titration technique), and pulse current test are quantitatively performed. By the constant current charge and discharge test, it is possible to measure the lithium plating and stripping capacity by increasing the current density (C rate). The capacity by the electroplating increases with increasing the *C*-rate, but, the stripping capacity is maintained in spite of the increase of plating capacity, because the plated lithium can be transferred into the graphene layers spontaneously until the graphite is fully lithiated. In the GITT test, the polarization of lithium plating is smaller than the polarization of lithium intercalation (80-90%). The pulse resistance by the pulse current is measured at charging and discharging with various currents, respectively. The pulse resistance during charging (lithiation) is typically higher than that of discharging (delithiation), but the difference in pulse resistance between charging and discharging is abruptly decreased at the high current condition of 10 *C* because of the extra current flow by the occurrence of the lithium plating. The occurrence of the lithium plating during the high charging current pulse is also confirmed by the appearance the new shoulder-peak in the voltage transient after current pulse.

The lithium electroplating and stripping reaction can be detected qualitatively and quantitatively by the proposed electrochemical analysis.