東京大学
微細構造解析
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東京大学微細構造解析プラットフォーム
公開講演会

"Understanding the Effect of Additives in Li-ion and Li-Sulfur Batteries by Operando ec-(S)TEM"

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The high demand for new energy storage materials has created the need for novel experimental techniques that can provide real-time information on the dynamic structural changes and processes that occur locally at the electrode/electrolyte interface during battery operation. The recent development of *in-situ* liquid electrochemical stages for (scanning) transmission electron microscopes ((S)TEM) enables fabrication of a "nano-battery" to study the details of electrochemical processes under *operando* conditions. However, high complexity of electrochemical process during the battery cycling requires careful calibration of the system prior to *in-situ/operando* observations to circumvent i.e. e^--beam damage of the electrolyte and artifact affecting the electrochemical cycling. Therefore, affecting stability and introducing varies degradation mechanisms in battery electrolytes. Here, we describe the effect of the electron beam in the *operando* observations and determine the condition to minimize electrolyte damage. In particular, we demonstrate application of an *in-situ* liquid electrochemical (S)TEM cell paying attention to rechargeable Li-ion battery and alternative systems such as Li-sulfur and Li-O_2. The full operation of these complex systems is yet not fully understood and typically involves multi-step electrochemical reduction/oxidation reactions, which often lead to lithium dendrite formation and require an increased fundamental understanding to bring beyond Li-ion technology to wide-spread commercialization similar to Li-ion batteries. There are many strategies to improve the interfacial stability of the Li anode and control/suppress Li dendrite growth, which is highly dependent on nature of electrolyte itself, such as mixture of different electrolyte solvents, salts and additives (e.g. HF, $LiNO_3$ etc). Here we use an *operando* electrochemical cell (*ec*-cell) in the STEM to investigate the role of electrolyte additives on the initial stages of Li deposition/stripping and the SEI layer formation. As a test of the fundamental process, we compare two commercially used electrolytes, electrolyte used in Li-ion battery contacting controlled trace-amounts of water (10 ppm and 50 ppm) with electrolyte used in Li-sulfur battery in the presence of $LiNO_3$ additive to understand the mechanism of Li dendrite nucleation and growth.

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