Toward in-situ observation of Li-ion distribution in Li-ion batteries

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The Li-ion battery is one of the most widely-used secondary batteries due to its high energy density and small memory effect. In order to further improve its performance, detailed understandings of various processes taking place in the battery are necessary. We are making use of nuclear material analyses techniques [1, 2] to visualize the meso-scale distribution of Li, which is one of the key factors in evaluating the performance of the Li-ion batteries. The Li-ions in the battery electrodes can be measured by analyzing the high energy radiation and particles produced in nuclear reactions between Li and high energy protons.

We have used the proton micro-beam of TIARA [3] to measure the Li-ion distribution in the battery electrodes with the spatial resolution of 1 μm. With PIGE (particle induced gamma-ray emission), the cross-sectional distribution of the Li-ions in the $LiCoO_2$ positive electrodes have been successfully measured, and its dependence on various parameters such as the electrode thickness and the charging speed has been clarified [4]. Also the dependence of the relaxation of the Li-distribution on the electrode materials ($LiCoO_2$ and $LiFePO_4$) has been measured. These observations are compared with the numerical simulation of the Li-ion batteries based on electro-chemical processes.

For more realistic evaluation of the battery performance, it is desirable to observe the Li-ion distribution during charge and discharge processes in the working batteries. One of the promising approaches is the use of (p, p) nuclear reaction to characterize the Li- depth profiling without the necessity of cutting and /or perturbing the sample.

In the symposium, we will report our approaches toward in-situ observation of the Li-ion distribution in the Li-ion batteries.

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