In operando measurement of Li reaction distribution on large scale battery using high energy X-rays

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We have been developed high energy X-ray Compton scattering imaging system which enables us to visualize lithium reaction distribution upon local area of the batteries in operando condition [1-3]. Advantage of the Compton scattering imaging is that this system uses high energy X-rays which over 100keV as incident X-ray. High energy X-rays have high penetration power, hence, enable us to measure lithium reaction on the electrode under non-destructive condition. Moreover, we can quantitate lithium concentration in charge-discharge process from the line-shape of Compton profile obtain from Compton scattering technique. In this study, Compton scattering imaging system reveals the behavior of lithium reaction in the edge of the electrodes and measures lithium reaction distribution along the cross-section direction of the electrodes in 5Ah crass layered cell. Compton scattering experiment was performed on the BL08W beamline at the SPring-8. High energy X-rays, 115keV, was irradiated on the sample layered cell, and scattered X-rays were detected by 9 segments pure-Ge solid state detector (SSD) which arranged 90 degrees direction to the incident X-rays. The observation area was determined by the entrance slit system upstream of the layered cell and a collimating slit which arranged between the layered cell and the Ge SSD. The size of the slit is 20μm height, 500μm width and 500μm depth. The sample cell was constructed by 9 layers of $LiNi_{0.3}Mn_{0.3}Co_{0.3}O_2$ as positive electrode and 10 layers of graphite as negative electrode. The cell was mounted on a movable z-stage, and Compton scattered energy spectrum was measured by scanning with the X-ray beams along the vertical direction.In order to investigate lithium reaction in the edge of the electrodes under charge and discharge state, we measured Compton scattering energy spectrum at 0.5mm and 2.5mm from the edge of positive and negative electrodes on first layer. We found that Compton scattered intensities obtained from negative electrode does not correspond to the electrochemical charge-discharge state at the position of 0.5mm from the edge in spite of the Compton scattered intensities obtained from both electrodes correspond to the electrochemical charge-discharge state at the position of 2.5mm. Here, the Compton scattered intensity almost proportional to electron density of the matter. This result to be concluded that the length of positive and negative electrodes is different in the sample cell. Next, we measured Compton scattering energy spectrum to show lithium reaction distribution on first layer. We found that the reaction occurs from the region of the electrode near the separator in both positive and negative electrodes and after that the reaction diffuses inside of the electrode. This result shows that it is important to precision control of porosity because magnitude of the reaction of negative electrode is smaller than that of positive electrode. In this study, Compton scattering imaging is powerful technique to visualize lithium reaction distribution for the large scale batteries.

Bibliography

[1] M. Itou et al.; J. Synchrotron Rad., **22**, 161 (2015).

[2] K. Suzuki et al.; J. Appl. Phys., **119**, 025103 (2016).

[3] K. Suzuki et al.; J. Synchrotron Rad., **24**, 1006 (2017).