MLF Experimental Report	提出日 Date of Report 2017/07/26
課題番号 Project No. 2017A0236 実験課題名 Title of experiment Observation of Li in electrochemically charged cathode and anode in lithium-ion battery 実験責任者名 Name of principal investigator Izumi Umegaki 所属 Affiliation Toyota Central Research and Development Laboratories, Inc.	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/（BL No.） D2 実施日 Date of Experiment 2017/04/27-2017/05/01

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

(1) Li-ion battery pouch cells

(2) A set of components of Li-ion battery pouch cell (except liquid electrolyte)

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

We have performed an elemental analysis with muonic x-ray (μXEA) on a test pouch Li-ion battery, which is composed of 100 μm thick cathode and anode, separator, and Al laminate sheets. By changing the momentum of incident negative muon from 18 to 26 MeV/c, the position that the muon stops at can be adjusted in the sample, that is, from a front side of the pouch cell to the other side. The sample was put in an Al holder with a capton window, whose size is 50 mmϕ. The sample and the holder were installed in an Al chamber. The Al chamber was evacuated down to 10^{-4} Pa before opening the gate valve.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

The muonic x-ray was detected by Ge semiconductor detectors that arranged around the Al chamber, with synchronizing with the frequency of 25 Hz of the muon pulse in J-PARC.

Figure 1 shows the muonic x-ray energy spectrum for the pouch test Li-ion battery with the momentum 20 MeV/c. The value of the momentum was calculated by the PHITS program [1], and it was also confirmed that most of peaks observed with the momentum of 20MeV/c were assigned as Li, Ni, Co, Mn, and O from cathode material. The peaks of Al from the sample holder and the sample chamber were also observed. We have clearly observed a peak of Li at 22 keV. It is noted that the improvement of increasing the number of available muons in D2 area leads to a success in observing this peak in 13 hours.

Figure 2 shows the momentum dependence of the intensity of the peak of Li observed at 22keV. The vertical axis is normalized by 90000 pulses, which is corresponding to about one hour, whereas the horizontal axis is the incident momentum, that is, the depth from the front side to the back one. We have successfully observed Li in the test pouch Li-ion battery by μXEA. This result leads to a future μXEA on a Li-ion battery under working condition.

【Reference】[1] T. Sato *et al.*, Nucl. Sci. Technol. 50:9, 913-923 (2013).

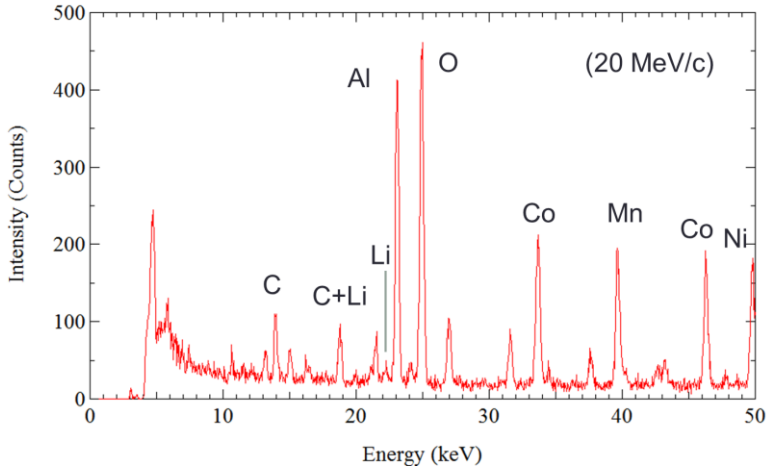

Figure 2 The μXEA spectra obtained for the test pouch Li-ion battery with the incident momentum of 20MeV/c.

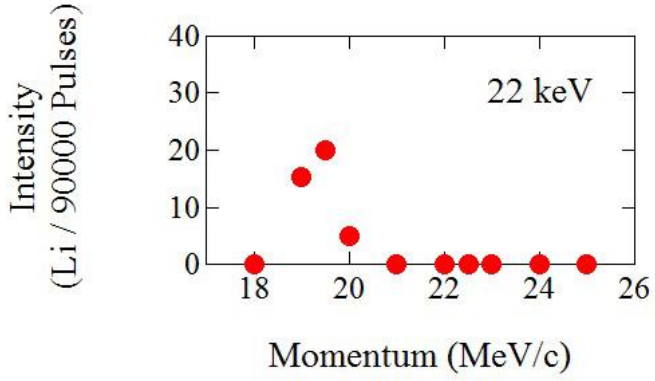

Figure 1 The relationship between the momentum of negative muon and the intensity of the peak of Li observed at 22keV.