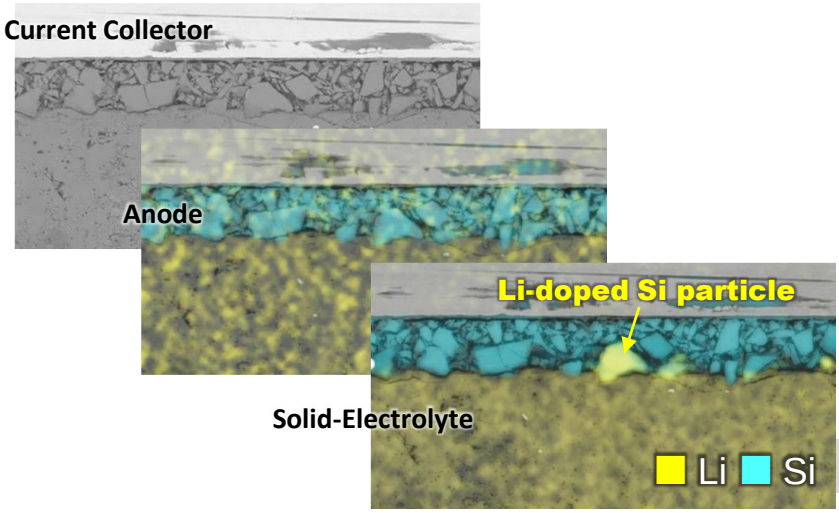
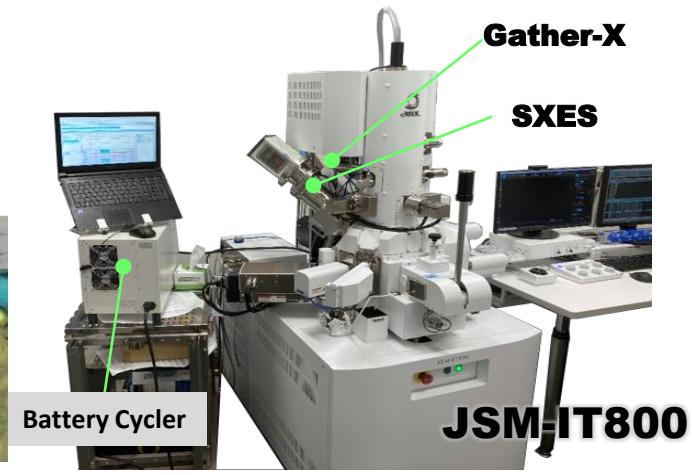
Battery Analysis SEM

In situ charging / discharging Analysis system for LIBs

SEM-EDS in-situ Li mapping



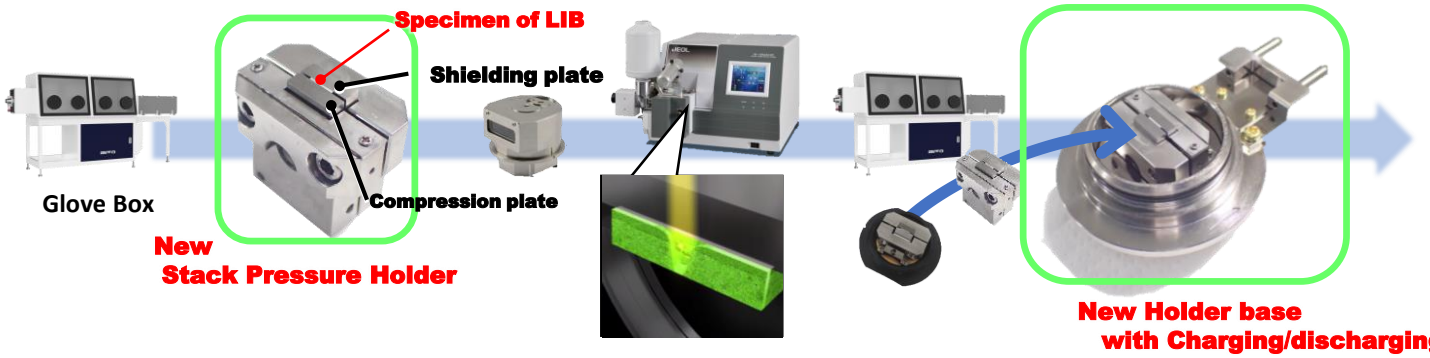


This system reveals lithium behavior inside the battery during charging and discharging and has following features:

1) **Visualization of Lithium behavior with SEM-EDS live imaging during charging and discharging.**
2) **Easy transfer of cross-sectioned samples from cross-section polishing tool to the SEM with air isolation using common stack pressure holder and capsules.**
3) **Flexibility for those using battery cyclers. The Customer can connect their preferred battery cycler on this system.**

New Devices for in-situ Analysis

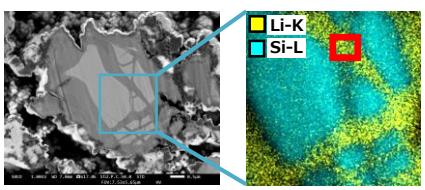
➢ New Devices to enable Charging/Discharging in SEM

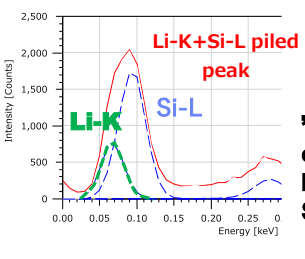


New Device Features – Holder / Holder Base –

- **Uniform high stack pressure – From CCP air-isolated processing to SEM observation –**
  ***ASSB requires high pressure in order to minimize interface resistance.**
- **Enable Cross-section processing with CCP**
- **Charging and discharging available – Connector to Battery Cycler included–**

➢ *Li-K direct detection in Silicon Anode by Gather-X*





Gather-X

"Gather-X", windowless EDS can detect low-energy X-rays (such as Li) by removing the window. Spectral deconvolution is built into this software.

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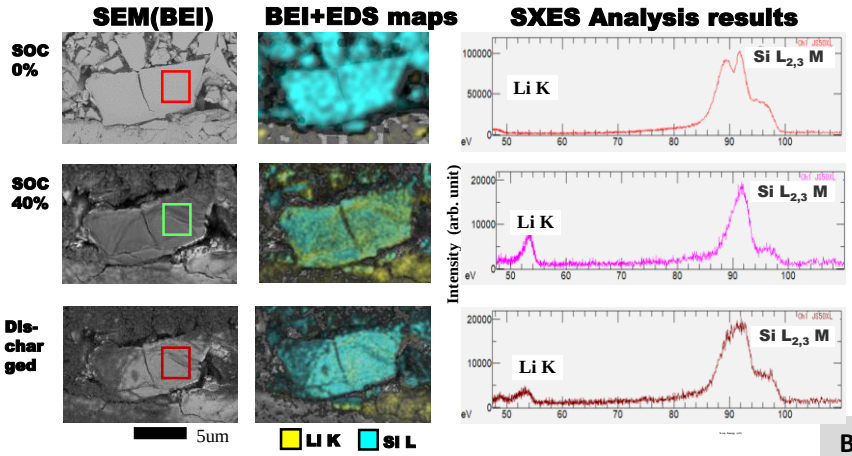
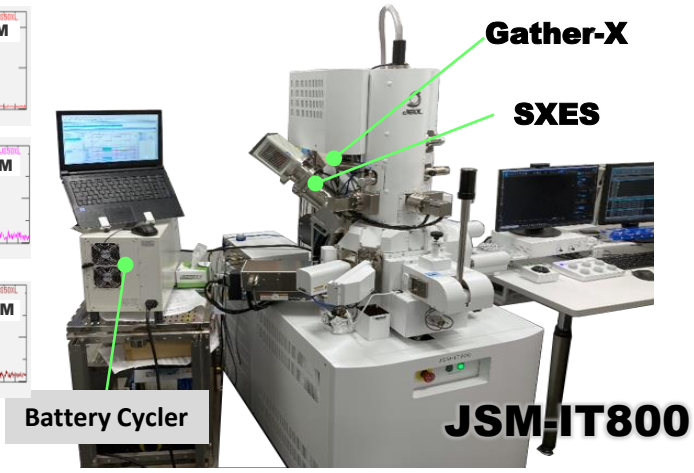
SEM-SXES in-situ Chemical State



Sample Courtesy : Prof. Atsunori Matsuda,
Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology,

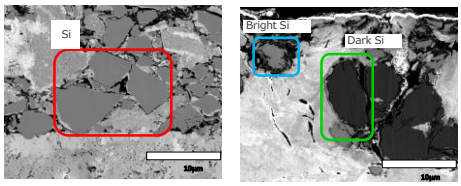


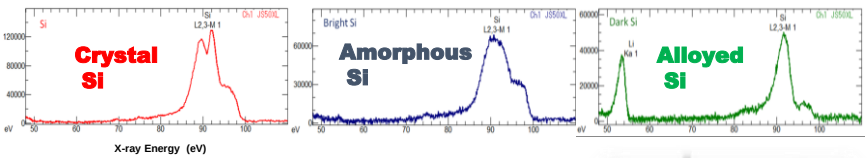
Above figures show data on battery status during charging and discharging using this system. These figures show several SEM images, EDS elemental map of Li detected at each time, and SXES chemical state analysis results of Si. In the SEM images, regions where Li intercalates with Si are darkened, and these regions are linked to the EDS Li distribution results. These SXES results show the crystalline state of Si during charging. Before charging, it has the same spectrum as crystalline silicon. The structure of the silicon changed during charging, reflected in the spectrum. Its spectrum suggests an alloy of Li and Si. Furthermore, the SXES spectrum shows that it became amorphous after discharging.

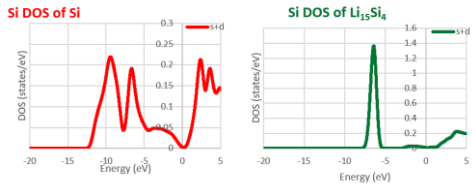
The newly developed system, when combined with existing technology, is expected to be highly effective in analyzing the behavior of Li and negative electrode Si in all-solid-state batteries.

➢ *Chemical State of Silicon particle by SXES*

(soft X-ray Emission Spectroscopy)







SXES enables us to confirm chemical state. Thanks to its high energy resolution, spectra reflect DOS ; Density Of States. Lower left graphs show the simulated DOS for Si and Si_4Li_{15}. Both results match the shape of the SXES experimental spectrum.

➢ *System Component*

Analysis Instrument	**JSM-IT800 series**
Analysis Spectrometer	**EDS : "Gather-X" windowless EDS** **SXES : SS-94000SXES**
Cross-Sectioning	**Cooling CP with Air-isolated IB-19520CCP**
In-situ Holder	**Stacking pressure Holder Holder Base**

Contact Information