

# Application and development of electron energy-loss spectroscopy

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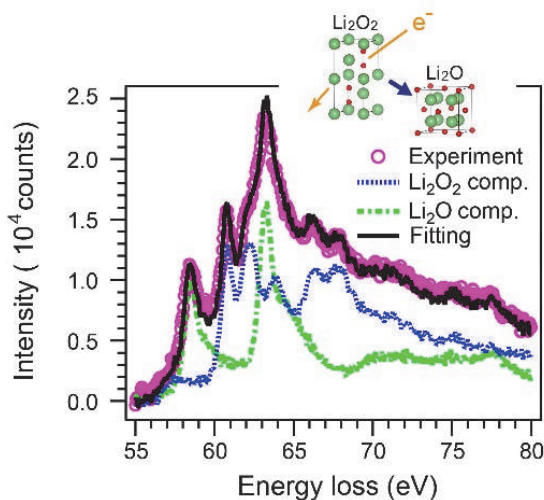
## Background

- Needs for analyzing electronic states at the nano/subnano meter scale.
- High energy resolution EELS using an advanced monochromator.
- Needs for analyzing materials of sensitive to air or electron beams.

## Aim

- Analyzing & imaging local electronic structures using high energy resolution EELS.
- Analyzing anisotropy & dispersions using scattering-vector dependent EELS.
- Development & application of EELS for materials of sensitive to air/electron beams.

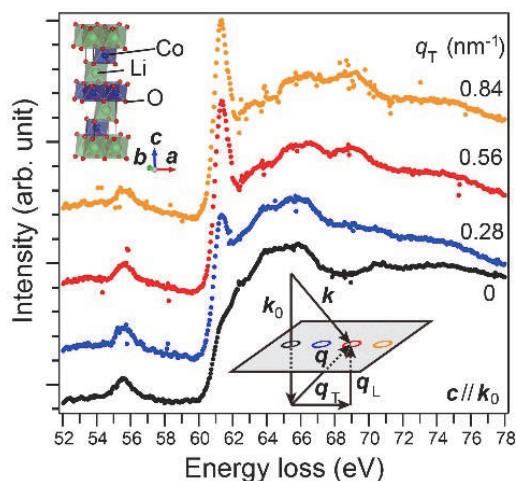
## Advanced Research Topics



$\text{Li}_2\text{O}_2$ , a discharge product for lithium-air batteries, is electron-beam sensitive. Using EELS, we quantitatively analyzed the transformation of  $\text{Li}_2\text{O}_2$  into  $\text{Li}_2\text{O}$  by electron irradiations. A component analysis in the figure above indicates that 40% of  $\text{Li}_2\text{O}_2$  changed into  $\text{Li}_2\text{O}$ .

## Publications

- J. Kikkawa et al., Phys. Rev. B, in press (2018).
- J. Kikkawa et al., Jpn. J. Appl. Phys. **57**, 035802 (2018).
- J. Kikkawa et al., J. Phys. Chem. C **119**, 15823 (2015).



Using scattering-vector dependent EELS, we identified Li  $K$  edge anisotropy in  $\text{LiCoO}_2$ , a positive electrode material for lithium ion batteries. The anisotropy originates from a difference between parallel and perpendicular components of Li  $2p$  states.

## Summary

- High energy resolution EELS was applied to Li  $K$ .
- A quantitative EELS analysis was performed for materials of sensitive to air & electron beams.
- An anisotropic Li  $2p$  state was clarified using scattering-vector dependent EELS.

## Research outcome

- Ultra-high energy resolution EELS and imaging.
- Measurement technology without exposure to air and using low-dose electron beams.
- Programing for advanced measurement.