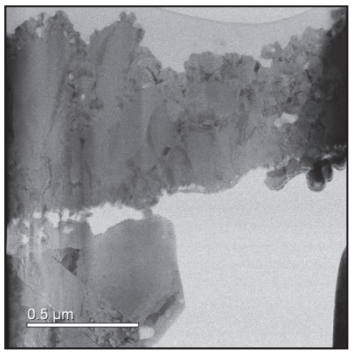
Evaluation of Cu oxides with (S)TEM

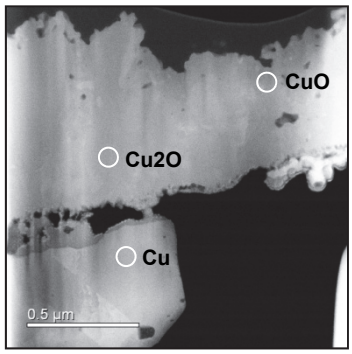
Examples of evaluation for oxidation states at nm area with (S)TEM are shown. Chemical states mapping are acquired with composition analysis by EDS(including quantification) and EELS combining with multiple linear least-squares(MLLS) fitting analysis. Crystal structure identification by electron diffraction are also available.

Observation of Cu-oxides by STEM

BF-STEM Image



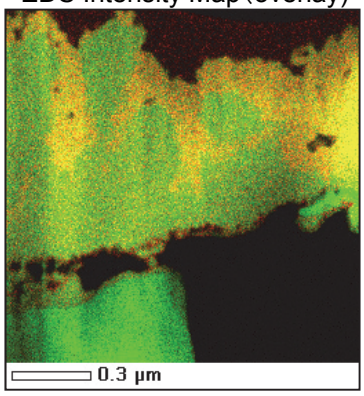
HAADF-STEM Image



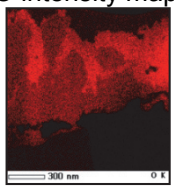
There are no information for oxidation states in STEM images.

Quantitative composition mapping by STEM-EDS

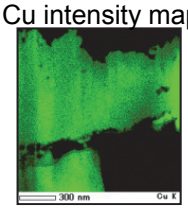
EDS Intensity Map (overlay)



O intensity map



Cu intensity map

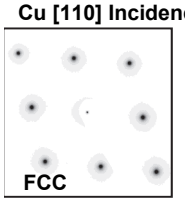


Quantification

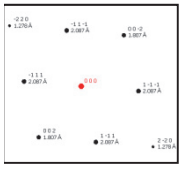
Identification for Cu-oxides by Electron diffraction

SAED pattern from each point in above HAADF image.

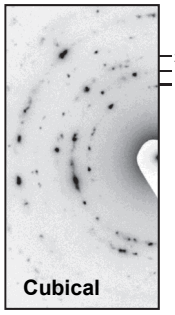
Cu [110] Incidence



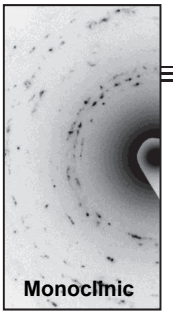
Cu [110] Incidence Simulation Result



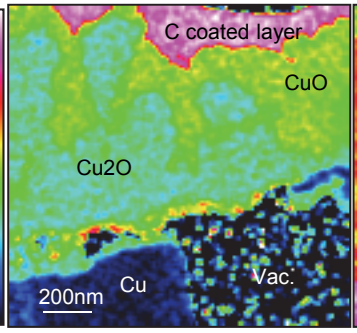
Cu2O



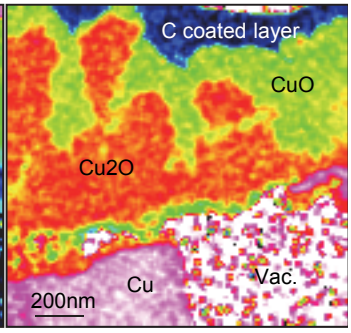
CuO



O quantitative map



Cu quantitative map

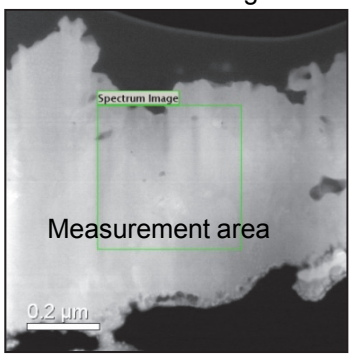


ED provide information about crystal structures

Quantitative EDS mapping clarify the distribution of Cu, CuO and Cu2O respetctively. This method can apply for thicker(^100nm) foils of samples.

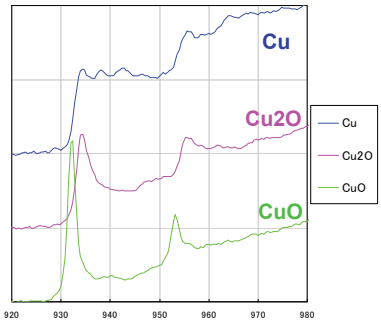
Chemical states mapping with EELS

ADF-STEM Image

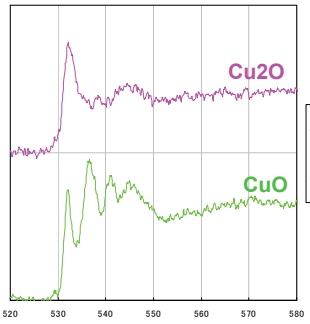


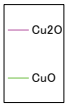
ELNES(Energy Loss Near Edge Structure)

Cu-L edge



O-K edge

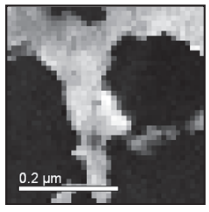




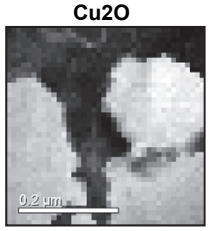
MLLS Fitting at Cu-L edge

MLLS:Multiple linear least-squares

CuO



Cu2O



Chemical States map can be acquired with peak separation utilizing difference of form of Cu-L edge between each cu-oxides.