

Energy-Filtering TEM

Goal

The purpose of this experiment is to introduce you to the powerful techniques of EFTEM (energy-filtering TEM) enabled by the post-column imaging energy filter (Gatan “GIF”) of the Tecnai F30. You will learn how to setup the Tecnai F30 for EFTEM, how to record zero-loss-filtered images, and how to perform elemental mapping via ESI (electron-spectroscopic imaging).

The specimen of this laboratory is a cross-sectional specimen of a Si single crystal substrate with a thin epitaxial layer of Cu₂O grown on top of it.

Experiment

1. Consult the online documentation for the recommended operating conditions for EFTEM. This concerns the condenser aperture, the gun lens setting, and the extractor voltage.
2. Start the microscope, load the specimen, load appropriate FEG registers, and check the basic alignment of the microscope.
3. Locate a region where the Cu₂O/Si interface traverses a relatively thick part of the TEM foil, conventional bright-field imaging yields a somewhat diffuse image.
4. After choosing an appropriate magnification, perform a zero-loss peak alignment. (Note that this alignment must be performed for every new setting of the magnification.)
5. Record conventional and (unfiltered) bright-field images.
6. Choose zero-loss filtering and record corresponding filtered images, such that you can compare the effect with and without the filter in your report.
7. Locate an area where the Cu₂O/Si interface traverses a thin part of the TEM foil – near the edge of the hole. Recall that ESI requires a very thin specimen area.
8. Choose a moderate magnification, e. g. 100 \times .
9. Be sure to spread the beam sufficiently, such that the images you are going to record do not include any shadows (this would interfere with the cross correlation procedure by which the system the images recorded with different positions of the energy-filtering slit).
10. Record elemental ratio maps of oxygen, silicon, and copper using the two-window method.
11. Record elemental maps of oxygen, silicon, and copper using the three-window method by choosing the appropriate settings via the computer interface.
12. Try out the effect of choosing different settings (different sets of parameters for recording with the same energy-loss edge as well as selecting a different energy loss edge).
13. Record a thickness map of the same region. Here, you are working with the zero loss peak and the low-loss region. Make sure to choose a very short exposure time! (e. g. 0:05 s).

Report

- No more than 5 pages, please!
- Include your images and take a critical look at them!
- Describe the set-up and operation of the imaging energy filter.
- Describe how to obtain *high-quality* bright field images.
- Describe how to obtain elemental maps.
- Comment on experimental difficulties and pitfalls.
- Try to produce a color map (red, green, blue) showing the spatial distribution of O, Si, and Cu.