SkyScan 1273

How to set up a scan?

Method note

MCT-141

Innovation with Integrity

microCT

Overview workflow

1. Sample preparation and mounting on a sample holder
2. Sample positioning in the SkyScan 1273
    i. Fix the sample holder on the sample stage
    ii. Close the door
    iii. Switch on the x-ray source
    iv. Position region of interest sample in the camera field of view
    v. Set the pixel size
3. Optimize transmission through the sample
    i. Set the correct filter
    ii. Adjust voltage
4. Update the flat-field correction
    i. Remove the sample
    ii. Update the flat-field manually or automatically
5. Reposition the sample (cfr step 2)
6. Evaluate image
7. Set acquisition settings in ‘acquisition’ menu
    i. Rotation step
    ii. Frame averaging
    iii. Random movement
    iv. 180/360° scan
    v. Partial width/offset scan
    vi. Further advanced scanning modes – See Method notes
8. Start scan

Workflow in detail

1. Sample preparation and mounting on a sample holder

i. Different samples require different preparation/mounting techniques:
   - Scan dry or wet?
   - Scan at room temperature or keep the sample cool/frozen?
   - Scan in air, water, ethanol…?
   - Prevent movement of the sample!
   - Mount using polystyrene foam, double sided tape, wax, …?
   - …

ii. If possible, resize your sample but make sure the size is still large enough to give representative data.

iii. The ideal shape of an object is a cylinder.

iv. Position the sample in the center of rotation to avoid misalignment artifacts and to allow for maximal zooming.

2. Sample positioning in the SkyScan 1273

i. Fix the sample holder on the sample stage.

ii. Close the door.

iii. Switch on the x-ray source.

iv. If possible, make the sample rotate completely inside the field of view:

- The parts of the sample that rotate outside the field of view can't be reconstructed due to missing data.
- Use the micro positioning of the stage to center the sample as best as possible. Drag and drop while holding the ctrl key pressed to adjust or use the micro positioning window, found under options.
- When an object is larger than a field of view on a specific pixel size, one still has the option to run an offset scan (point 6).

v. Define a pixel size:

- The pixel size is defined by a combination of the sample position ('zoom') and the camera binning mode.
- Note that the same pixel size can sometimes be set using different camera binning modes. In these cases, camera binning will reduce the scan time and increase the signal to noise ratio.
- To avoid a collision between the sample and the source when zooming in, the sample dimensions can be entered into the 'sample size' box in the bottom right corner of the acquisition software, which is prompted upon closing the door. This way the freedom of travel for the stage will be limited by the sample size.
- To balance resolution and X-ray power, the system has three available X-ray spot sizes which correspond to different pixel size ranges. When selecting a spot size mode, the power of the system will be adjusted to create the desired X-ray spot size. For imaging below a 10um pixel size, the small spot size should be selected. Imaging above 30um pixel size allows you to use the large spot size. For anything else, use the medium spot size.

3. Optimize transmission through the sample

One key aspect of microCT imaging is partial absorption of X-rays in the sample. Too much transmission will reduce the contrast between different densities, while a low transmission will increase the noise level in the images. The transmission should be evaluated by inspecting the profile line in the acquisition software (activated by a single right click on the projection image). Adjust filter and voltage settings to get a minimum transmission between 10 and 50% (aim for 30% if possible). Note that these parameters should be adjusted for the highest dense part/angle in/of the sample.

i. Set the correct filter

- A filter absorbs X-rays below a certain energy level and thus increases the average energy of the X-ray beam. As a result, applying a (thicker) filter will increase the transmission through the sample and reduce beam hardening artifacts.
- The SkyScan 1273 has 8 filter options (no filter, 0.5mm Al, 1mm Al, 1mmm AL + 0.2mm Cu, 0.5mm Cu, 1mm Cu and 2mm Cu).

ii. Adjust voltage

- Changing the applied voltage will change the average energy of the X-ray spectrum. Increasing (decreasing) the applied voltage will increase (decrease) the average energy of the X-ray beam and thus increase (decrease) the transmission through the sample.
- Guidelines for the combination of filter and voltage

Filter	Voltage
No filter	40-60 kV
0.5 mm Al filter	50-70 kV
1 mm Al filter	60-90 kV
1 mm Al + 0.2mm Cu filter	80-100 kV
0.5mm Cu filter	90-110 kV
1mm Cu filter	100-120 kV
2mm Cu filter	110-130 kV

4. Update the flat-field correction

The flat-field correction is a background correction that will make sure the background is always represented in the same grey level and will level out interpixel intensity variations that would otherwise result in ring artifacts. As such the flat-field correction is essential when a comparison is needed between multiple scans generated on different time points. It is of importance to update both the bright field (with the source on) and dark field (with the source off) images. Further reading on this specific topic is possible in method note 129.

One should always update the flat-field correction upon changes in the following settings: filter, voltage, current, power of the source (spot size) and camera binning mode.

i. Remove the sample from the field of view (either lower the sample below the camera field of view or take it out of the micro-CT).

Manual updating:

ii. Inactivate the flat-field correction by double clicking in the top left corner of the field of view (indicated by 'ff' or 'flat-field correction off').
iii. Adjust the exposure time and current in the 'scanning settings' menu to get an average transmission in air between 40 and 70% without flat-field correction (aim for 60%). The 'scanning settings' menu is activated by pressing the "Ctrl+Alt+Shift+S" key combination.
iv. If you adjusted the X-ray voltage/current manually, be sure to update your new values in the 'scanning settings' window accordingly or the previous default values will be loaded during the flat-field acquisition process.
v. Activate flat-field again by double clicking in the top left corner of the field of view (indicated by 'ff' or 'flat-field correction off').

Automatic updating:

vi. Update the flat-field correction in the 'update flat-field references' menu, 'update Flat-Field for current mode', found under options.
Note that in this menu one has the option to define the exposure time automatically. In case this option is ticked, steps ii.-v. can be skipped. In addition, the sample stage is moved completely down during this procedure, allowing small enough samples to be automatically removed from the field of view and also step i. can be skipped.

Note that this flat-field correction can be saved and re-used for similar samples. We recommend updating the flat-field correction at the start of the day, and when the above described settings are changed.

9. Reposition the sample

Cf. step 1 and 2.

10. Evaluate image

Evaluate the transmission through the sample (cfr step 3). If the transmission is fine, proceed to step 7. If the transmission is too low or too high, repeat steps 3 and 4.

11. Set acquisition settings in 'acquisition' menu

One can select in which folder the dataset will be saved, as well as enter a dataset name. The following parameters need to be specified:

i. Rotation step

- A smaller rotation step will increase the signal to noise ratio. Preferentially lower the rotation step (instead of increasing frame averaging) for low dense samples when the signal to noise ratio is too low.
- Guidelines for choosing the rotation step

Binning	Rotation step
1x1 binning mode	≤ 0.3°
2x2 binning mode	≤ 0.6°
4x4 binning mode	≤ 0.8°

ii. Frame averaging

- A higher number for frame averaging will increase the signal to noise ratio. Preferentially increase the frame averaging (instead of decreasing the rotation step) for high dense samples when the signal to noise ratio is too low.
- Guidelines for choosing the frame averaging

Binning	Frames
1x1 binning mode	4-8
2x2 binning mode	2-6
4x4 binning mode	1-4

iii. Ring Artifact Suppression

Can be activated to reduce ring artifacts.

iv. 180/360° scan

360° scans should be selected for samples consisting of a combination of high dense materials inside low dense materials to avoid depletion artifacts. 180° scans are generally sufficient for samples with reasonable homogeneity and will reduce your overall scan time compared to 360° scans.

v. Partial width/offset scan

By activating the partial width, the width of the projection imaged is cropped. Make sure the sample rotates within the new field of view (boundaries) at all angles. By activating the partial width, the rotation step can be slightly increased.

The offset scan mode will increase the width of the field of view by doing 2 scans subsequently side by side (change of the camera position). To preserve the signal to noise ratio, make sure you also decrease the rotation step with a factor 2.

vi. Further advanced scanning modes, including Spiral scanning and HART scanning are possible with the SkyScan 1273, which are addressed more in detail in method note 106 and 123 respectively.

12. Start scan