Quick Guide to Measurements

Bruker ContourX-500 3D Optical Profilometer

1. On Left panel select Measurement Type (PSI or VSI)
2. Select initial magnification to be 10x and zoom lens 1x
3. Load sample onto stage. For thin samples use 3 or 4 glass slides to lift the sample
4. Focus
    a. Find an edge or feature with adjustment of x-y and Z
    b. Find desired feature to measure and adjust Z to the highest contrast point of the fringes
    c. Select “Auto Tip/Tilt” in the top instrument bar
    d. Select desired final magnification and zoom lens
    e. Adjust Z again. If fringes are still more than 2 or 3 on the screen, run the auto tip/tilt again.
    f. Adjust light intensity to an appropriate level
5. Under Measurement Parameters
    a. PSI
        i. Check Illumination -> default
        ii. Uncheck everything else
    b. VIS
        i. Check Illumination -> default
        ii. Check Image Enhancement -> auto
        iii. Set Processing Method to VSI
        iv. Set Backscan and Length defaults to be 5 um
            1. Adjust as necessary to encompass the entire z height of your sample
6. Select Single acquisition
    a. If you are getting black patches in your acquisition
        i. Ensure fringes are at their highest contrast point
        ii. Raise or lower illumination
        iii. Adjust Backscan and Length to be larger (for VSI mode)
7. In the Data Analysis tab, view your data
    a. On the right under “Data Analyzer” select “open saved analyzer recipe”
    b. Open:
        i. “Basic Stats and Step Height” for imaging devices and features
        ii. “Subangstrom surface roughness analyzer” for flat, surface roughness measurements
    c. Right click on “Terms Removal“ in the data tree
        i. Select edit settings
        ii. Select desired leveling for data
8. Save data, export pictures and line profiles as desired
9. Raise Z and bring x-y stage towards you to unload sample

Bruker ContourX-500 3D Optical Profilometer

1. Purpose

Standard operating procedure for the ContourX-500. Optical Profilometry uses Coherence Scanning Interferometry (CSI) to image a sample, creating a topographical map with angstrom level Z resolution. As the objective lens is moved a change of intensity due to interference will be observed for each pixel when the distance from the sample to the beam splitter is the same as the distance from the reference mirror to the beam splitter. If the objective is moved downwards the highest points on the surface will cause interference first. This information can be used to build up a 3D map of the surface.

2. Scope

This SOP is intended for general purpose use of the ContourX-500.

3. Prerequisites

Users must have cleanroom access.

4. Responsibilities

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5. Procedure

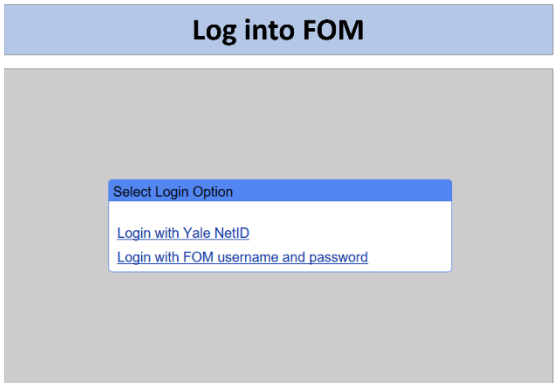
Before You Start:

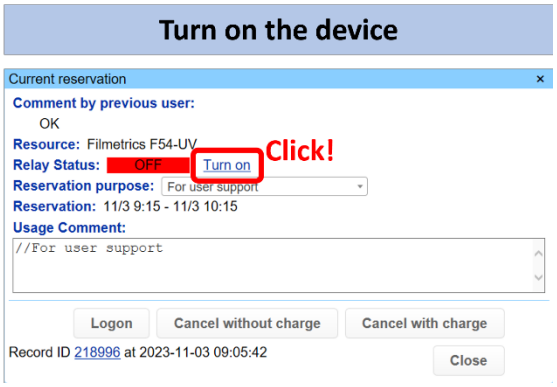
Warnings

- Refrain from touching the objectives to avoid damaging the system.
- This system uses an automated stage. Do not move it by hand and be sure all hands and objects are clear when starting the software and scanning.

Start Up Procedure:

1. Log into FOM to enable the hardware.



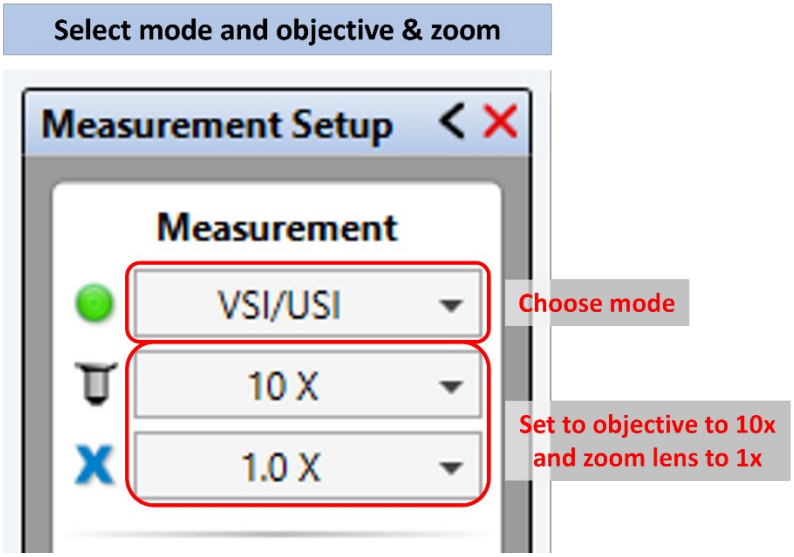


2. Open the Vision64 software available on the desktop if it was not already open and wait for the software to initialize.

Sample loading:

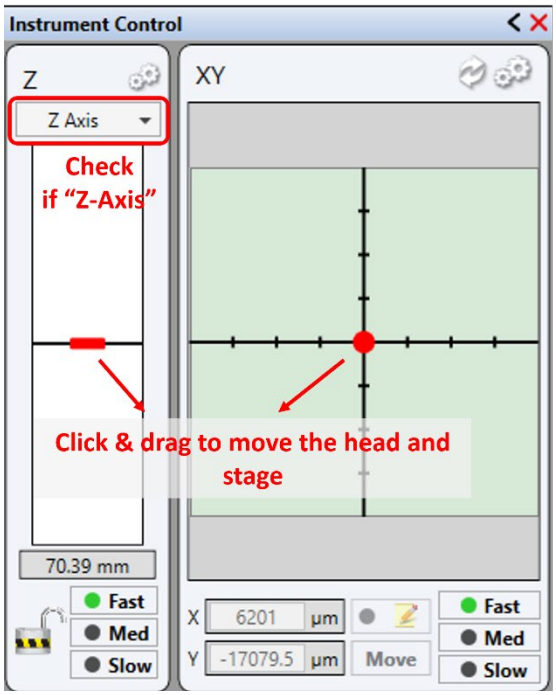
1. In the "Measurement Setup" panel situated on the left side, choose your desired mode, which can be either VSI/USI or PSI.
    a. VSI/USI mode is suitable for features larger than approximately 100 nm in the Z-axis.
    b. PSI mode should be selected for features measuring less than 100 nm in the Z-axis.
    c. USI is a high-resolution scan, similar to PSI, but utilizing the full range of VSI. Please be aware that conducting a USI scan will require more time. To switch from VSI to USI, navigate to the “Measurement Parameters” tab and adjust the Processing Method to USI.

    Select an initial magnification of 10x and set the zoom lens to 1x.

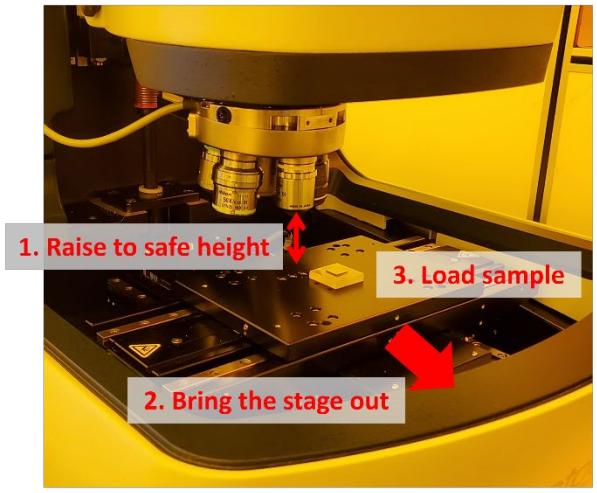


2. Adjust the Z-height of the head and the XY motion of the stage using the "Instrument Control" panel located on the right side. Ensure that the Z-motion control is set to "Z-axis" mode. Next, raise the head to a safe height for loading the sample and position the stage for convenient sample loading.

Control head and stage position

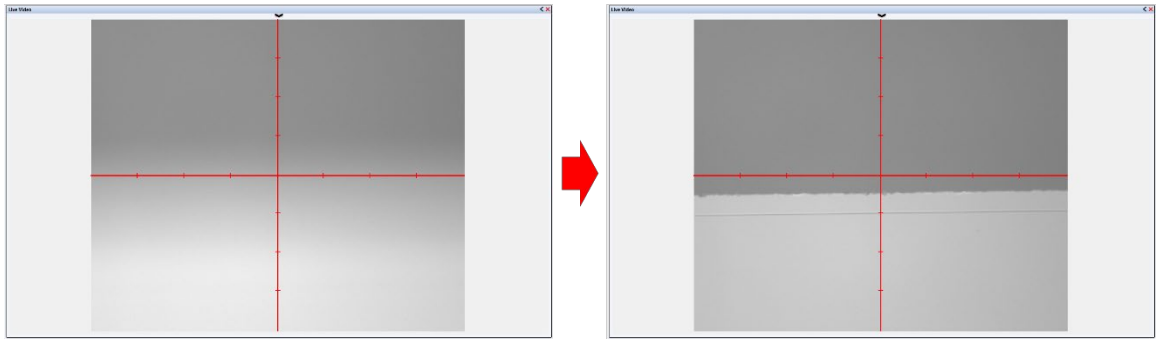


Load your sample



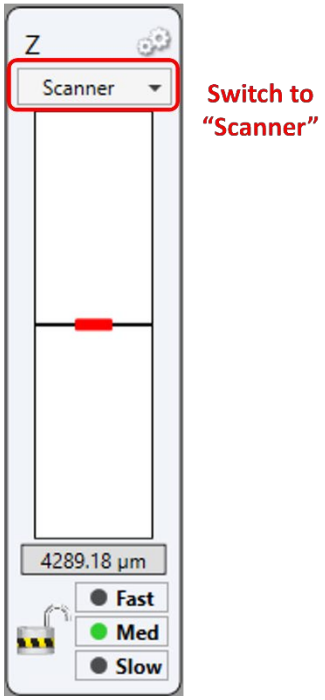
3. Adjust the XY controls to position the focus on an edge of your sample. Utilize the appropriate speed settings: Fast, Medium, and Slow as you approach your sample. Be cautious to avoid any collisions between the lens and your sample during this process.

Focus on sample edge

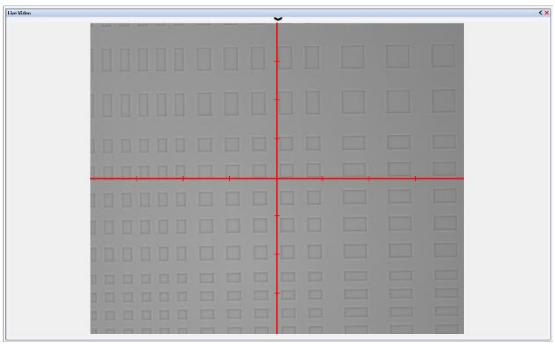


4. When you are reasonably in focus, change the Z control from Z Axis to Scanner. Locate your desired feature to image.

Switch to "Z-Axis" to "Scanner"

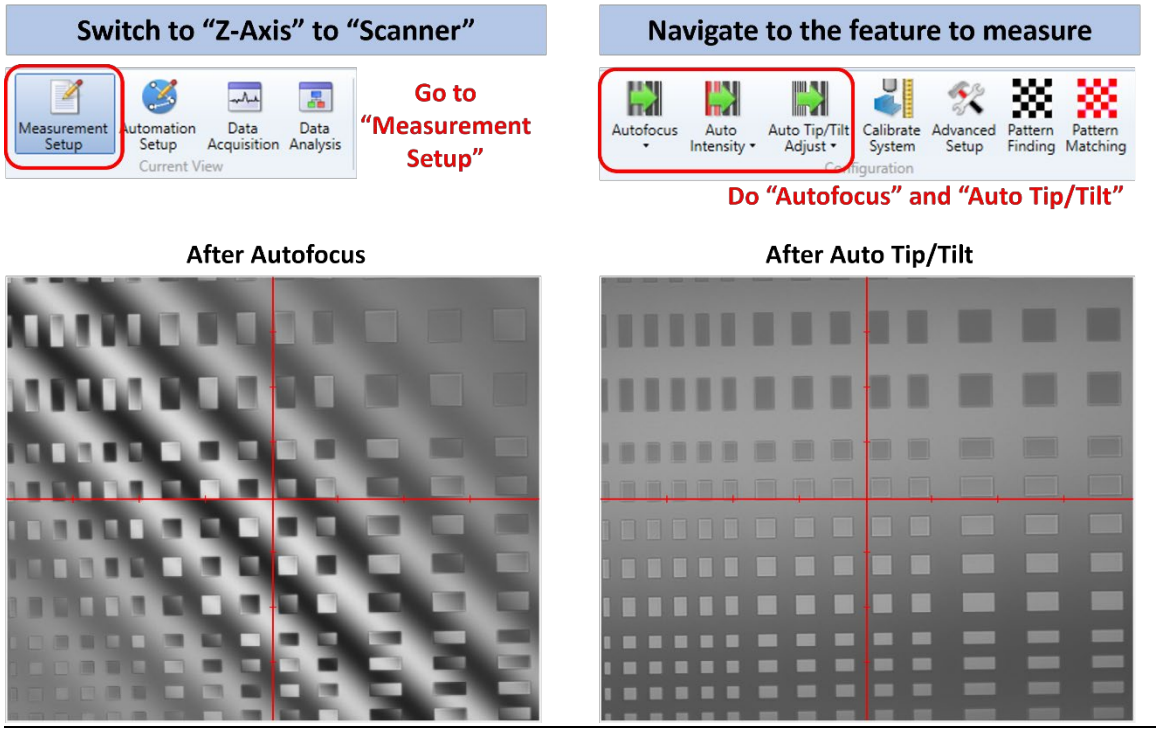


Navigate to the feature to measure

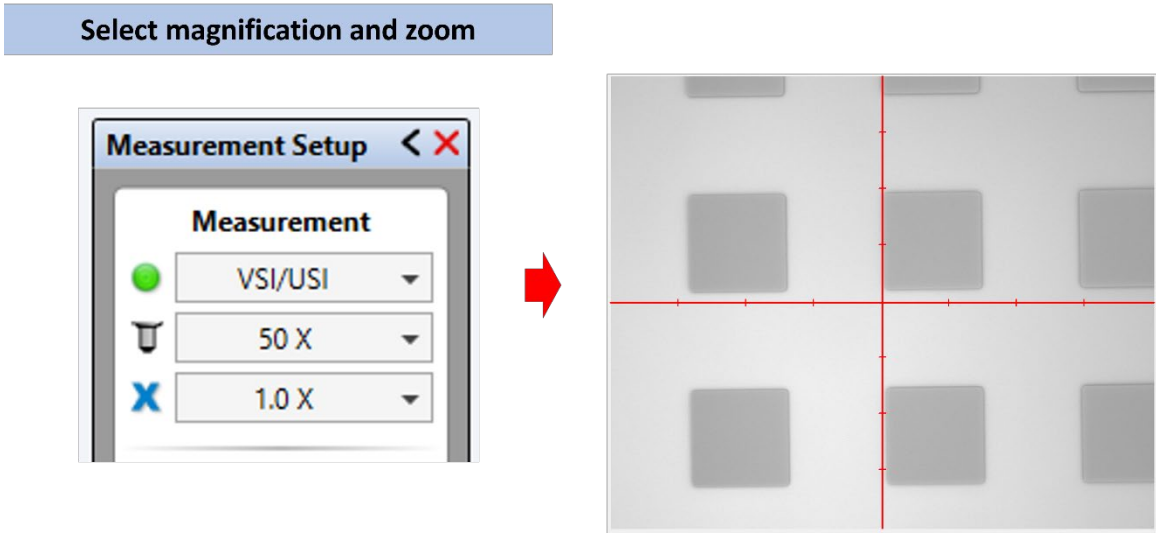


Measurement:

1. Fine-tune the Z controls to achieve the desired focus. Click on "Measurement Setup" in the top toolbar, and then initiate the "Autofocus" and "Auto Tip/Tilt" functions. These actions will optimize the interference fringe intensity and ensure that the fringe expands to its maximum extent across the field of view. If the "Autofocus" or "Auto Tip/Tilt" function fails to work, you can attempt to manually adjust the focus and tip/tilt settings. Alternatively, you may report the issue to the staff for assistance. Adjust light intensity.



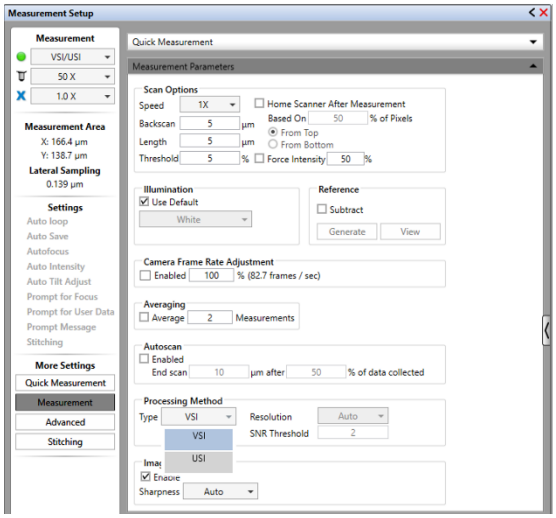
2. In the "Measurement Setup" panel, choose your preferred magnification and adjust the zoom as needed.



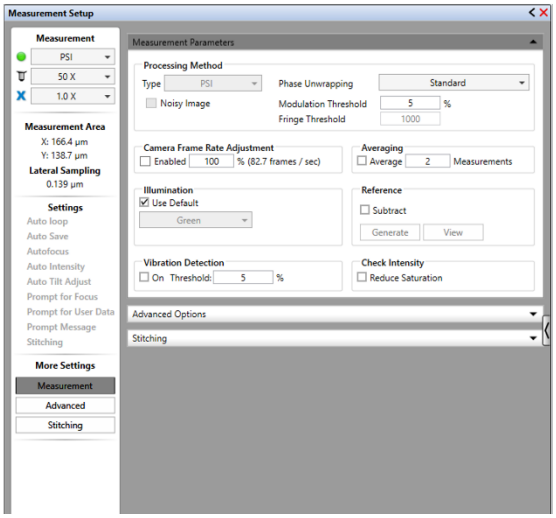
3. In the "More Settings" panel located in the lower right corner, click on "Measurement" to open the "Measurement Parameters" window. Modify the measurement parameters according to the following guidelines:

a. Select either Green or White light for “Illumination”. Green light offers finer focus and performs better with small features that have large step heights. White light is more suitable for surface roughness measurements.
b. Enable "Averaging" to conduct multiple measurements and reduce noise levels. You can specify the number of averaging cycles.
c. For VSI/USI mode, you can switch between VSI mode and USI mode under the "Processing Method" option.
d. In VSI/USI mode, adjust the "Backscan" and "Length" parameters as needed to cover the entire Z height of your sample. The default value for both is 5 µm.

Measurement Parameters for VSI/USI

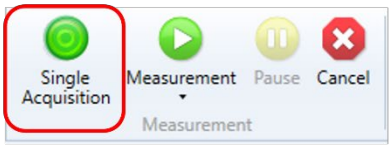


Measurement Parameters for PSI

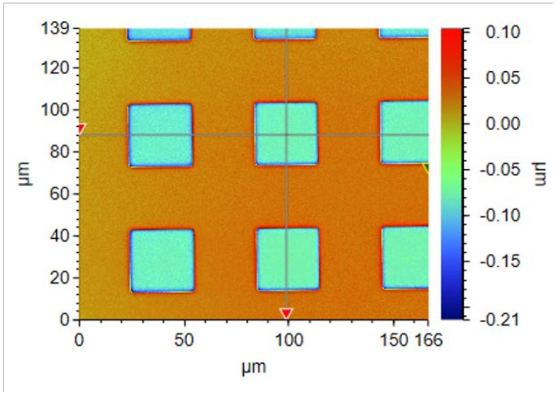


4. Perform a "Single Acquisition" to assess the accuracy of your measurement parameters, focus, tip-tilt, and light intensity settings. Make necessary adjustments to the measurement settings based on the results obtained from the single acquisition.

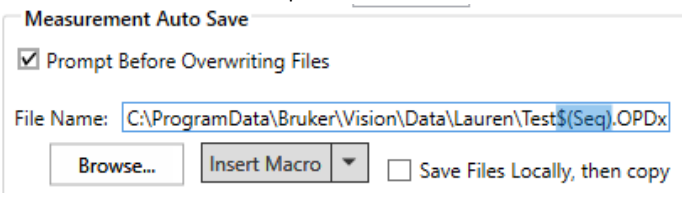
Take "Single Acquisition"



Check if measurement is succesful

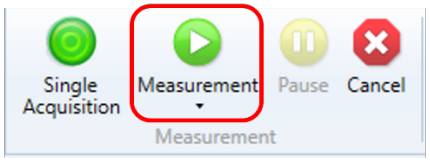


5. Set up your final measurement. Enable **Auto Save** under **Advanced Options** to save your measurement(s). Select the appropriate folder and file name. Insert a macro at the end of your file name for multiple file saves.



6. Once you have established appropriate measurement parameters, focus, tip/tilt, and light intensity settings, proceed to conduct the measurement by pressing **Measurement** under the **Instrument** tab..

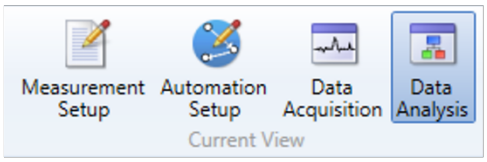
Hit "Measurement"



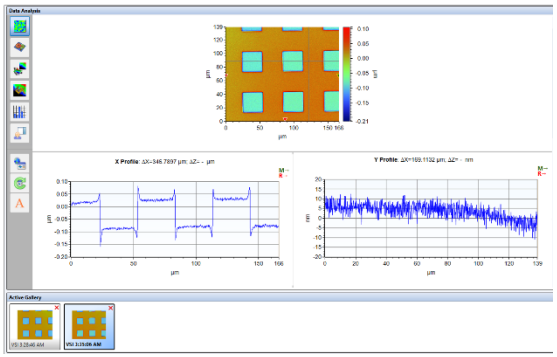
Data Analysis:

1. Go to Analyze -> Data Analysis. Select your view options (2D, 3D or both) from the left panel.

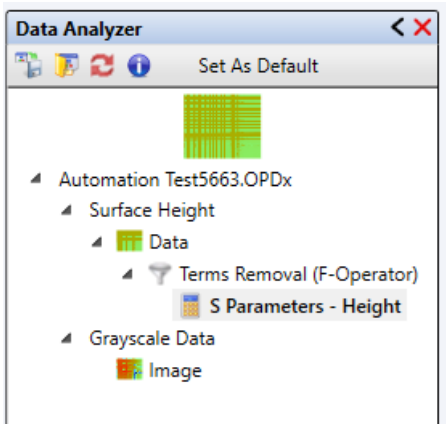
Go to "Data Analysis"



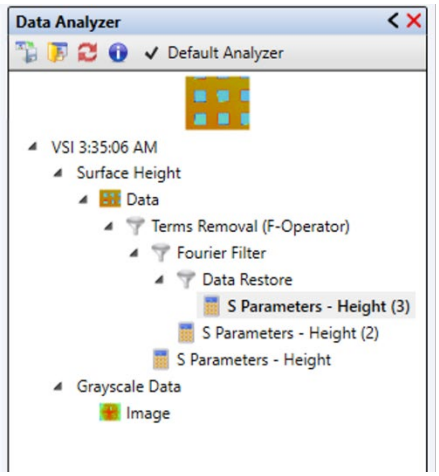
Select your view

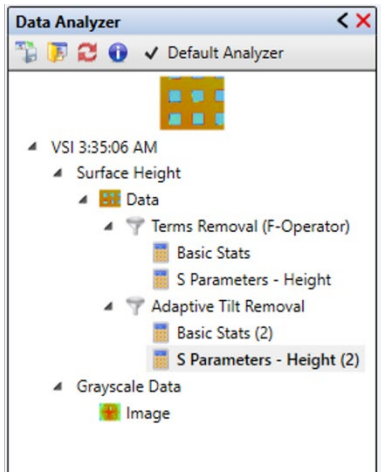


2. Set up your analysis tree in the Data Analyzer panel. Highlight Data in the tree and select your desired filter from the 3D Filter panel.



   a. The most common is Terms Removal (F-Operator) to flatten the data.
   b. Highlight your filter and select a 3D Analysis option. Basic Stats and S Parameters – Height are good options for step heights and surface roughness measurements.
   c. Use a Gaussian Regression Filter to remove noise for Z measurements of single angstroms to a few tens on nm's.
   d. By right-clicking on the filter, you can adjust parameters for the selected filter.
   e. You can apply multiple filters in series or in parallel (for easy comparison).





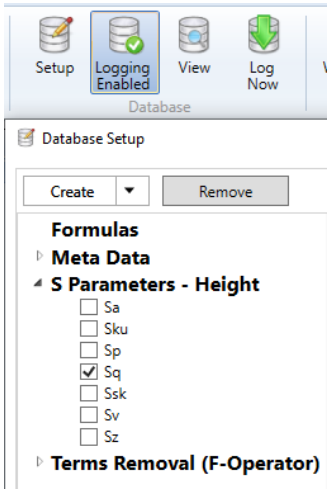
f. You can save or load the analysis recipe for future use.

3. Manipulate 2D and 3D profiles as needed. Right click to save individual profiles. Use the save option to save your entire data set + analysis set up.

Advanced Applications:

Auto Loop

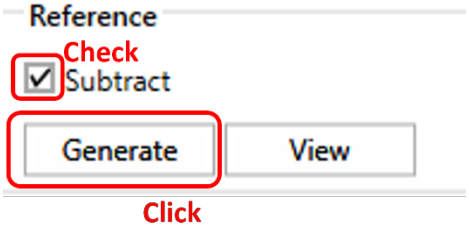
1. To log a list of multiple measurements, select Auto Loop and specify the number of measurements. Under the Analyze tab, enable Logging.
2. Set up your analysis tree in the Data Analyzer panel under Data Analysis (see next section). Go to Setup next to the Logging option and check the parameters you want to log. Select Continue Only Saving Database and choose a folder and file name to save your data.



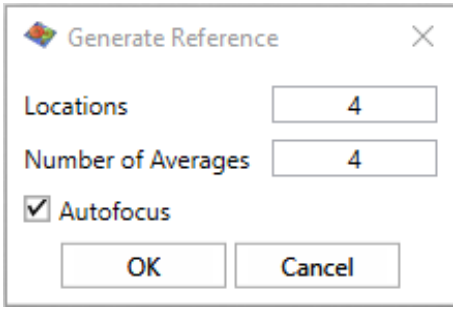
Reference

When measuring the roughness of a surface with roughness less than 1 nm, it may be necessary to correct for image distortion caused by the morphology of the reference mirror in the interferometer. To achieve this correction, the user should capture multiple images at different locations, and the software will identify common features among these images, which are likely caused by the reference mirror.

1. For surface roughness measurements, check **Subtract** under **Reference** in the "Measurement Parameters" and select **Generate**.

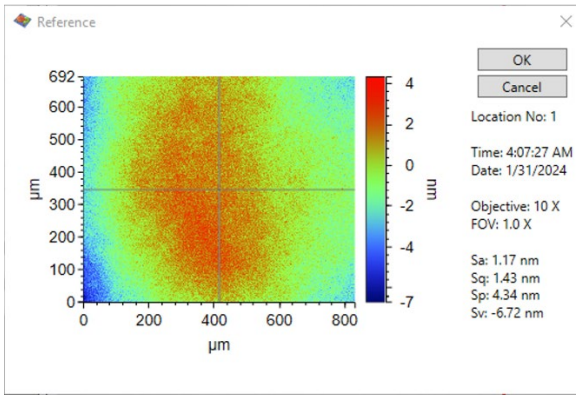


2. If the "Generate Reference" window pops up, choose the number of locations to measure and the number of averaging cycles. Using a higher number of locations and averaging cycles leads to improved subtraction but increases processing time. Recommended values are 3/3 or 4/4.



3. Press "Ok" to measure the image, then move by ½ field of view for each. Repeat this process.

Measured reference image



4. This subtracts any topography influencing the image from the reference mirror in the objective.

Image without subtracts

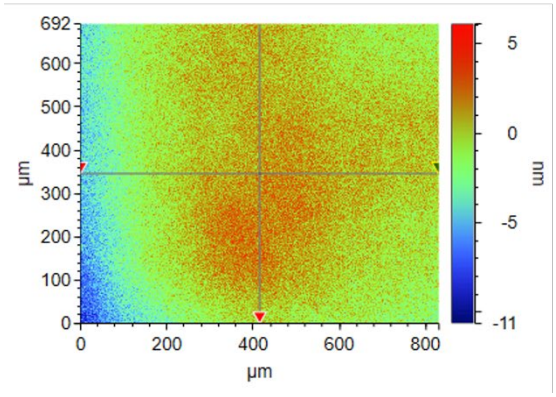
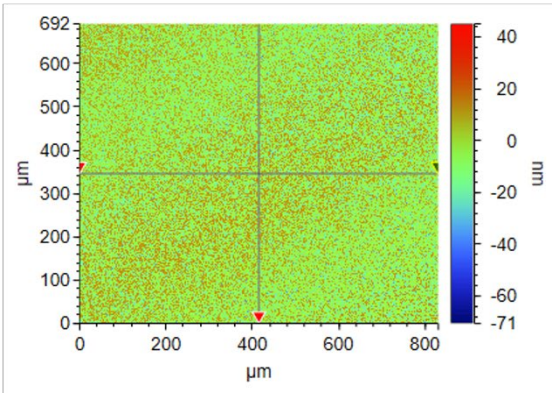


Image with subtracts



Stitching

1. For the larger are scan, enable Stitching in the "Measurement Setup" panel.
2. In the Stitching drop down menu, select your image type (most common is Rectangular).
3. Select Teach to specify the image area intended to be stitched. Follow the prompts starting with the bottom left-hand corner of the image area. Adjust the image
4. Overlap Area % as desired. Note the number of rows and columns in the full measurement, more images will take longer. For large areas enable the Autofocus.

Automation

1. Go to the "Instrument" -> "Automation Setup" tab.
2. Select Recipe in the top left of the panel. Open a previous pattern or create a new one as an XY Scatter or XY Grid.

3. Add locations by manually inputting coordinates or clicking the Add Current Location button.
4. For non-centered samples you may need to reset the reference point to capture all your desired points. Select the Reset Reference from Stage Position button.
5. For large areas ensure that Autofocus is enabled in the measurement setup tab.

Unloading:

1. Change the Z control from Scanner to Z Axis.
2. Move your sample towards you with the XY control and retrieve your sample.
3. Lower the light Intensity to 0.
4. Leave the software running.

6. Quick Tips

Getting black patches in a single acquisition measurement?

- Ensure fringes are at their highest contrast point
- Raise or lower illumination
- Adjust Backscan and Length to be larger (for VSI/USI mode)

Seeing a 'fringe' in your single acquisition?

- Adjust tip/tilt to better zero the fringes

For super polished substrates/surface roughness measurements

- Subtract a reference measurement
- Use the average function
- Use the Gaussian Regression Filter

Proper use of the Gaussian Regression Filter

- Use Long wavelength and a 2 um size

Standard Analyzer Recipes

- Basic Stats and Step Heights.ANRCP
- Subangstrom Surface Roughness Analyzer.ANRCP