ACTIVITY/PROJECT SPECIFIC PROCEDURE

SP 12-34
IMAGING USING THE VERTICAL SCANNING INTERFEROMETER
Revision 2

Effective Date: March 21, 2023

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(printed name) (signature) (date)

1.0 Purpose and Scope

The purpose of this procedure is to establish a method for users from Sandia National Laboratories (SNL) to obtain images of a solid sample surface using the Zygo NewView 8300 Interferometer to support the Department of Energy’s Waste Isolation Pilot Plant (WIPP). Once the images have been obtained, the user can then quantify surface roughness, measure height differences of objects on the surface, and characterize surface features.

This SP is a simplified version of the startup, image acquisition, and analysis routine. For more information regarding the operation and use of the interferometer, the user is directed to the User Manual. A PDF version of the User Manual is located on the desktop of the interferometer computer with the title “NewView 8000 Operating Manual”.

Acronyms and definitions for terms used in this procedure may be found in the Glossary located at the Sandia National Laboratories (SNL) WIPP Online Documents web site.

1.1 Instrument Description and Components

The interferometer is a microscope that uses white light (with a green filter) and different sized objectives to analyze the three-dimensional, surface structure of samples. The interferometer can be found in NPHB Room 801 and utilizes Mirau objectives to analyze the small displacements, refractive index changes, and surface irregularities of solid objects. A full overview of the instrument setup as well as the individual parts are displayed in Figure 1, Figure 2, and Figure 3.
Figure 1: Zygo NewView overview.

Figure 2: Zygo NewView optical profiler overview.

Figure 3: Joystick controller.

Joystick knob: Twist to move up/down and push to move in the corresponding direction

X-Y button: Activates x-y stage

Theta button: activates theta stage (not equipped in NPHB)

Emergency Stop button

Speed Buttons: Slow, Medium, and Fast

P-R button: activates pitch (y) /roll (x) stage

Z-stop: controls Z-stop function for the z-axis
2.0 Implementation Actions

2.1 Responsibility

The Principal Investigator (PI) or designee is responsible for implementing the requirements of this procedure.

The Technical Staff is responsible for performing the measurements following the requirements of this procedure, documenting all required information described in this SP, and assuring the latest revision of this document is followed.

If the procedure cannot be followed as written, the user has the responsibility to stop work and resolve all concerns with the PI/designee or safety committee, as appropriate, prior to proceeding with the work.

2.2 Qualification and Training

All users must receive on-the-job training from the lab manager, equipment technical owner, or another approved designated worker in order to operate the instrument in relation to WIPP relevant work. The training will follow the guide located in Appendix A and shall be recorded using Form NP 2-1-2 before being submitted to records as outlined in NP 2-1, Qualification and Training. On-the-job training shall be completed once the trainee is able to operate the instrument with this SP as a reference and without any assistance from the trainer.

2.3 Safety

The activities described in this SP shall conform to SNL Environmental Safety and Health (ES&H) programs. Users shall adhere to all laboratory ES&H procedures described in the Technical Work Documents and Standard Operating Procedures of the laboratory in which the equipment is used.

2.4 Data Collection and Storage

Data collected on this instrument will be recorded on printouts, in scientific notebooks (SN), or on electronic media. Notes on what measurements were performed will be documented in the scientific notebook.

Electronic files should be saved to the instrument desktop and the files themselves are recommended to follow the following naming convention: YYYYMMDD_ProjectName_UserIntials. An example of the naming convention is as follows: 20230101_FeCorrosion_AA.

2.5 Sample Preparation

There is no need for sample preparation, such as coating or chemical/physical processing, so the sample can be placed directly on the stage. However, the best results are obtained with flat samples that are well polished, have been handled with care, and have not been touched in zones of analytical interest.
2.6 Instrument Start Up

1. Turn on all components associated with the interferometer including the monitor and desktop. (Note: The desktop can be found underneath the interferometer in the cabinet seen in Figure 1.)
2. Log into the computer using the Zygo user account. No password is required for this account.
3. After your windows desktop loads, click the Mx Icon found on the desktop to open the software.
4. A prompt will then appear in the software with instructions to set the A and F stop on the instrument in the correct position for CSI measurements. On the right side of the Optical Profiler be sure the A-Stop and F-Stop knobs are pushed in towards the instrument. This indicates they are in the open position.

![Figure 4: Right side view of the interferometer, displaying optical profiler panel.](image)

5. If prompted to send all axes to the home position, then do so now by clicking **Yes**.

2.7 Z-Stop Setup

The Z-Stop is a safety feature that can be implemented to ensure the objective lens does not collide with the sample and/or stage. Z-stop will need to be reset if changing objectives or when swapping samples with differing dimensions. To set the Z-stop follow the steps outlined below.

1. Place sample on part stage.
2. Twist the knob on the Joystick counterclockwise to drive the objective lower. Stop when the objective is slightly closer to the sample than its working distance or there is only a small amount of space between them.
3. If the Z-stop button on the Joystick is lit green, then the Z-Stop is already set. Reset it by pressing the Z-Stop button twice, once to release the previous position (Z-Stop is blinking red) and twice to set the new Z-Stop height (Z-stop is solid red). If the Z-Stop is not already set then no color will appear, and the user will only have to press the button once to set the Z-Stop.
2.8 Calibration Check

As a prerequisite to analysis, a calibration check must have been performed in the last 6 months utilizing the vertical step height standard provided by Zygo. A calibration check can be performed sooner if desired and is recommended when the instrument has not been utilized for a significant period of time as the check verifies that accurate vertical height measurements will be taken, and that the uncertainty can be quantified.

The vertical step height standard seen in Figure 5 consists of a quartz plate in which a trough has been precision milled down the middle of the plate. The depth of this trough, $1.767 \pm 0.011 \mu m$, has been certified by Zygo and measurements against this depth will be made by the interferometer for the calibration check.

(Note: The standard is very delicate and therefore must be handled carefully during the calibration check. Be careful when removing the lid as it is very tightly held by the base and too much force may result in sudden separation and the possibility of dropping the standard resulting in damage. Also make sure to place the standard right-side up as placing it upside down may result in damage to the standard. If it is not clear which side the standard to use, place the standard in light and tilt slightly till troughs are visible.)

2.8.1 Calibration Check Procedure

1. Place the Step Height Standard on the part stage under microscope with the troughs facing up as described above.

2. Under the Calibration tab, select the 10X objective with the 0.5 zoom (thus, 5X magnification in total) and adjust the light by clicking the Auto LL button seen in Figure 6 box 4. The large box representing the live image should turn grey.
3. Select **Focus Aid** as seen in Figure 6 box 4. A dialogue box will prompt you to close the F-Stop. Pull the F-stop knob out on the Optical Profiler as seen in Figure 4 and click **OK**. The objective will then lower toward the sample.

4. Another live image box will appear that shows a circle. Twist the joystick counterclockwise to move the objective closer until a thin purple ring appears around the circle as seen in Figure 7. It is recommended that the speed is set to “Medium” on the joystick. Be careful that you do not strike the standard with the objective as you adjust the height of the objective if the Z-stop has not been set. (Note: If the image turns fuzzy then the objective is too close to the standard and needs to be moved away by twisting the joystick clockwise.)

5. Click the X in the upper right of the box to exit the Focus Aid. You will be prompted to place the F-Stop in the open position. Do so by pressing the F-Stop knob in on the Optical Profiler as seen in Figure 4. Click **OK**.

6. Click **Auto LL** again to adjust the lighting. If the light level is too high, adjust the light using the scale bar on the upper left-hand side above the Zygo symbol.

7. Use the joystick to move around on standard surface till troughs appear as seen in Figure 6 box 5.

8. Click the **Auto Focus** button seen in Figure 6 box 4. Fringes that are shown as alternating dark and light grey bands should now be visible. If not, twist the joystick both clockwise and counterclockwise until they appear. If the fringes are red, then the camera is saturated in light.
and the intensity needs to be turned down using the light scale seen in Figure 6 at the top of box 5.

9. Use the X and Y Focus/Tilt knobs seen in Figure 2 to adjust the stage tilt until the fringes are aligned either north-south or east-west (Note: It doesn't matter which direction you select). It is recommended to adjust the stage, so the fringes are relatively broad, with three or four bands in field of view as wide fringes indicate that the sample surface is nearly flat while thin fringes indicate significant tilting.

10. Click on Tool Calibrations on the left-hand side of the Calibration page as seen in Figure 6 box 1.

11. Set Acquisition Count to a minimum of 10. (Note: The more acquisitions acquired, the more accurate the measurement will be. However, more than 20 is unnecessary and therefore the acquisition count should be no greater than 20.)

12. Select Edit Masks below the acquisition count dialogue box. A new box will open with the live image on the screen. Check that the Mask Type on the right-hand side of the screen says Scan Cal Reference Mask and then place 5-10 squares outside of the troughs.

![Image of tool calibrations](image.png)

Figure 8: Adding the squares for the masks during the calibration check: 1) Inside the troughs for the test mask and 2) Outside the troughs for the reference mask.

13. After placing the reference boxes then change the Mask Type to Scan Cal Test Mask and place 5-10 squares inside the troughs. Exit out of the window after setting the boxes for the reference and the test.

14. Enter the height of the Step-Height Standard into the Certified Height dialogue box which is 1.767 μm. Also check that the Calibration Reference is Step Height Standard. (Note: Step Height Standard should be the only option during normal operation.)

15. Press Measure ScanCal. After measuring the standard, the Measured Height, Difference, and Percent Difference dialogue boxes should automatically populate with the corresponding values. The absolute value in the Difference dialogue box must be ≤ 0.011 μm in order to pass the calibration check based on the uncertainty provided by Zygo. If the absolute value is greater than 0.011 μm then repeat steps 12-15 with more reference and test masks. If after the second attempt the value is still out of range, then refer to the manual and contact Zygo if necessary. If the value is within range, then log this value in the appropriate Scientific Notebook and proceed with analysis as described in Section 2.10.

2.9 QC Standard Criteria

Follow Section 2.8.1 Calibration Check Procedure. The value in the Measured Height box will constitute the average vertical height difference between the 5-10 squares for the reference mask and the 5-10 squares for the test mask. This value must be $1.767 \pm 0.011$ μm to meet the acceptance criteria.
2.10 Sample Measurement and Analysis

The following sections address how to collect an image and two common methods for performing analysis: slice results and region segmentation.

2.10.1 Collecting an Image

1. Place the sample directly beneath the objective lens. Be sure the green light is in contact with the sample.
2. Click on the Measure tab. Select the desired objective and zoom under the tab to the left of the live image. If desired, set the Z-Stop limit to prevent striking the lens by following Section 2.7.
3. Click on Auto LL to adjust the light. Be sure no red color is present. Adjust the light intensity using the scale bar at the top of the image. If unable to focus manually, you may select the Auto Focus and follow steps 3-8 in Section 2.8.1.
4. Once the image is clear and is in an area or spot you would like to analyze, click the Measure button to obtain an image.

2.10.2 Analyzing an Image Using Slice Results

![Figure 9: Analyze tab after completing analysis using Slice Results: 1) Analysis type selection, 2) Command strip tab, 3) 3D image of the sample surface, 4) Graph and results of Slice Results analysis, 5) Alternate graphs of the sample.](image)

1. Click on the Analyze tab. A new command strip and three image boxes will appear when Surface is selected on the left side of the navigator box as seen in Figure 9. The largest of these is a 3-D image of the sample surface seen in box 3 of Figure 9. The sample surface can be interpreted as a height map with red representing relative highs and blue representing relative lows.
2. Click on the Linear button above the 3-D image. Drag and drop or adjust the pins on the ends of the line to the desired positions. A graph of the height profile along the designated line will appear below the 3D image as seen in box 4 of Figure 9. The graph will automatically update as the line is adjusted. (Note: Only one line can be created at a time.)
3. Above the image click **Slice Results** seen in box 3 of Figure 9. A table displaying relevant values including the peak to valley (PV), root mean square (RMS), and average arithmetic roughness (Ra) will appear next to the height graph as seen in box 4 of Figure 9. These are the parameters that are automatically populated but can be adjusted following steps a through c below:
   a. Left click anywhere in the table and click **Select Results**.
   b. A dialogue box will appear with many different results to select from including area, dimension, height, and hybrid parameters.
   c. After selecting the desired results, click **OK** and then close the dialogue box.

4. After the desired information and images have been created, the information can be saved as a .datx file for later reference. Other legacy data formats are also available in the software including .dat, .xyz, and .asc. To save data click the **Save Data** button found in box 2 of Figure 9 or use the keyboard shortcut ctrl+S. To save the information in another format not listed utilize another method such as screenshots.

2.10.3 Analyzing an Image Using Region Segmentation

![Figure 10: Analyze tab after completing analysis using Region Segmentation: 1) Analysis type selection, 2) Segmentation mode selection and mask configuration, 3) Graphs to display location of the test masks, 4) References configuration section, 5) Individual test results, 6) Summary of results.](image)

1. Click **Regions** to the left in the Navigator box as seen in box 1 of Figure 10 to switch to Region Segmentation analysis.

2. Check the **Segmentation On** box located underneath the image as seen in box 3 of Figure 10 to activate the dialogue boxes. Under segmentation options click on the **Segmentation Mode** drop-box seen in box 2 of Figure 10 and then select **Masks**.

3. Click **Configure Masks** as seen in the bottom of box 2 of Figure 10. The Segmentation Mask Setup will then appear in a new window.

4. The mask configuration box will be structured very similarly to the one used during the calibration check. Check that the **Mask Type** is “Test 1” before placing a square in the light gray area which corresponds to the relatively higher surfaces of the sample. More than one square can be placed if desired but only one is necessary per mask for accurate analysis.
5. Repeat Step 4 for all ten of the masks under Mask Type which are correspondingly labeled Test 1-10. For the most accurate analysis place the squares in different locations from one another for each test. (Note: You will have to select the square icon each time a new mask is selected.)

6. Exit out of the Segmentation Mask Setup window to save the selections made.

7. In box 4 of Figure 10 change the Define By drop-down to be defined by a mask which will cause any previous data populated to disappear until the reference mask is selected. Click Configure Reference... to create the reference mask.

8. Create one square in one of the dark gray locations of the sample as this represents the relatively lower surfaces of the sample. More than one square can be created but only one is necessary for accurate analysis. Close out of the Reference Mask window.

9. The results should now have repopulated in the regions table (box 5) and summary statistics table (box 6) as seen in Figure 10. To change the results generated follow the procedure below:
   a. Left click anywhere in the table and click Select Results or Select Statistics depending on what information needs to be adjusted.
   b. A dialogue box will appear with many different parameters to select from. Select the desired parameter by clicking on the corresponding check box or unchecking the undesired parameters.
   c. After selecting the desired results, click OK and then close the dialogue box.

10. After the desired information and images have been created the information can be saved as a .datx file for later reference. Other legacy data formats are also available in the software including .dat, .xyz, and .asc. To save data click the Save Data button found in box 2 of Figure 10 or use the keyboard shortcut ctrl+S. The only other data formats available in the software are .pdf and .xlsx for the tables created during analysis by utilizing the corresponding buttons in box 5 of Figure 10. To save the information in another format not listed utilize another method.

   2.11 Shutdown of Interferometer

   The system should be fully shut down whenever not in use by exiting from the program, which will also turn off the green light for the interferometer sensor, and fully shutting down the computer. The instrument can be left in the “on” position as the long-lasting LED light is rated for years, but this should only be done when expecting to use the instrument on consecutive days.

3.0 Records

The following records, generated through implementation of this procedure, shall be prepared and submitted to the WIPP Records Center in accordance with NP 17-1 (Records):

   QA Record
   - SN (Scientific Notebook)
   - SNS (Scientific Notebook Supplement)

   Non Quality (NQ) Record
   - Electronic media

4.0 Appendices

Appendix A: Zygo NewView 8300 Interferometer System Training Guide
# Appendix A

**Zygo NewView 8300 Interferometer System Training Guide:**

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