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ACTIVITY/PROJECT SPECIFIC PROCEDURE

SP 12-34
IMAGING USING THE VERTICAL SCANNING INTERFEROMETER
Revision 1

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1.0 Purpose and Scope

The purpose of this procedure is to enable the user to obtain images of a solid sample surface using the Zygo NewView 8300 interferometer. Once the images have been obtained, the user can then quantify surface roughness, measure height differences of objects on the surface (to the sub-angstrom level), and characterize surface features.

A PDF version of the User Manual can be found on the desktop of the computer that controls the interferometer. This SP is a simplified version of the startup and image acquisition routine, and for more information regarding the operation and use of the interferometer, the user is directed to the User 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.

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 worked as written, the user has the responsibility to stop work and resolve all concerns with the PI/designee or safety, as appropriate, prior to proceeding with the work.

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2.2 Qualification and Training

Users should not use this instrument without on the job training from an experienced user.

2.3 Safety

The activities described in this SP shall conform to SNL Environmental Safety and Health programs (ES&H). This document does not address ES&H issues. Laboratory ES&H procedures and specific instrument hazards are described in laboratory-specific TWDs and JSAs, which can be found at the listed website: http://tdb.sandia.gov/WIPP_ESHDocs/

2.4 Data Collection and Storage

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

2.5 Instrument Operation

The interferometer is a type of microscope that uses white light (with a green filter) and Mirau objectives (a 10X and 50X) to analyze the small displacements, refractive index changes and surface irregularities of a solid object. The solid can be crystalline or amorphous, natural or engineered, metal, glass, ceramic, mineral, concrete, etc. The only requirements for analysis is that the sample should have a flat surface, should be reflective with respect to light and small enough to fit on the stage. There are exceptions to even these “requirements” and, if an investigator is interested in an unusual application he or she should consult with an experienced user. The best results are obtained with flat samples that are well polished. There is no need for sample preparation, such as coating, chemical or physical processing, so that the sample that is to be imaged can be hand placed on to the stage beneath the objectives. Step-by-step instructions are given below, with those in bold representing instructions to which the user must pay particular attention.

2.5.1 Ensure that the sample lies clear of the objectives above it.

2.5.2 On the computer desk top, double click on the Mx icon (blue circle) to start the program. Be patient while the program loads!

2.5.3 The software will display a large panel in the “Measure” tab whose main features are three boxes that will contain three separate images. The largest of these boxes is on the left, the two smaller boxes will be stacked on the right. The microscope light will be on, so set the sample beneath the objective so that the light is impinging on it, if you have not done so already. On the joystick controller, it is recommended that the speed is set as “Medium”. Use the 10X objective to focus on the sample surface. If the 10X objective is not being utilized, click the “button” for the 10X objective, which can be found on the upper left-hand side of the panel in the “Measure” tab. **Set the Z-Stop limit (the lowest vertical position that the instrument can safely go without striking the sample) by turning the knob counter-clockwise until the objective is within ~10 mm of the surface. Press the Z-Stop button on the joystick twice (or until the light is a constant red).**

2.5.4 Click on “Automatic LL” (= Light Load) to adjust the light. The large box representing the live image should be medium grey, but neither too light nor too dark.

2.5.5 Select “Focus Aid” from the strip of commands on the upper part of the panel in the “Measure” tab. The head with the objective turrets will rise and a dialogue box will open that instructs the user to pull out the F-stop, which is on the right side of the head. Pull out the F-stop and then click “O.K.” and

the head will lower towards the sample. Another dialogue box will open that shows a purple ring (a representation of the light coming through the aperture on the objective).

2.5.6 Turn the Z-direction knob to the right (clockwise) until the ring fills solid purple. You should then be close to in-focus with respect to the sample surface. Click the 'x' on the far upper right-hand side to close the dialogue box. Another box will open to remind you to push in the F-stop knob. Push in the F-stop knob.

2.5.7 Click "Auto LL" again to adjust the light. If the light level is too high (which it normally is), adjust the light using the scale bar on the upper left-hand side just above the Zygo symbol.

2.5.8 Click "Auto Focus" on the command bar just above the image panels in the "Measure" tab. The instrument will bring the surface close to or at focus. (Note: If the instrument fails to bring the surface into focus, the sample may be too tilted. The user will have to level the surface using the knobs on the stage; see below. Also, if you have a very clear sample, such as glass, it is possible for a user to accidentally focus on the surface of the stage beneath the sample. If this occurs, the user should raise the instrument head by turning the knob on the joystick to the right, or clockwise, until the true surface becomes visible).

2.5.9 If the user is at or near the focus plane of the sample, fringes (shown as alternating dark and light bands) should be visible. If any of the fringes are red, then the camera is saturated in light, and the light intensity needs to be turned down. The orientation of the fringes will signal how much tilt there is on the sample surface and the direction of tilt. Using the knobs on the stage, adjust the stage tilt until the fringes are aligned either north-south or east-west. Wide fringes indicate that the sample surface is nearly flat, while thin, finely spaced fringes indicate significant tilting. It is recommended to adjust the stage so that the fringes are relatively broad, with three or four bands in the field of view.

2.5.10 While still in the "Measure" tab (which is where the user should be this entire time), click the "Measure" button (blue circle on the command strip on the upper right-hand side).

2.5.11 With the image obtained, go to the "Analyze" tab. There will be a new command strip above the image just collected. As in the case of the "Measure" tab, there will be three boxes with images, the largest of these situated to the left is a 3-D image of the sample surface. The sample surface can be interpreted as a height map with red representing relative highs and blue representing relative lows. In order to quantify the highs and lows, complete step 2.5.13 thru 2.5.16.

2.5.12 Click the icon on the command strip that looks like a set of 3-D boxes. The large image will now be a 2-D image, which is easier to work with. In order to determine the relative highs and lows along a profile, click on the "Linear" button on the command strip. Drag and drop the line to the desired position. A box will open up beneath the 2-D image that shows a height profile along the line just established.

2.5.13 Right click on this profile and a dialogue box will open. Go to "Inspectors" and highlight, which opens up another box. Choose "Show Inspector 2". Move the vertical lines along the profile to determine the difference between the maximum and minimum heights along the profile.

2.5.14 At this point, it may be desirable to remove the tilt (or "null" the image) on the sample profile. To do this, there is a panel on the left-hand side labelled "Navigator". Click on "Surface Processing". A dialogue box labeled "Sequence" appears. First, check the box on the lower end of the panel called "Immediate update". Then click on "Form remove" and another box opens. Check the box labeled "Higher Order" to average out the highs and lows. You can also check the "Filters" box to additionally smooth the data with a variety of filters. (A description of the use of filters is given in the User's Manual.)

2.5.15 It is sometimes helpful to right-click on the 2-D image and select “Show axes” to change units from the default micrometers to nanometers.

2.5.16 When the user is satisfied with the image, save the data as a.datx file. It may also be helpful to save the image in a format where it can be used as a figure in a document or PowerPoint presentation. The user can use the Microsoft snipping tool to select the desired part of the image and saved as a PNG file. Alternatively, the user can right-click on the image and save it under “Save Bitmap” on the drop-down file as a Jpeg.

2.5.17 Once satisfied with the data and images collected, the user can go back to the “Measure” tab. The user can then move to another location and acquire another image by clicking “Measure” or, if finished, he or she can minimize the application and manually remove the sample from beneath the objective (making sure to not touch the objective). Alternatively, the user can go to File and exit the application.

2.6 Instrument Startup

2.6.1 If the power to the building goes out, the system will have to be powered up and initialized. There is a power strip beneath the instrument on the right side inside the cabinet. Turn on the switch; a green light to the instrument controller will come on. Turn on the computer and allow it to boot up.

2.6.2 The screen will give the user two options to start up: Administrator or Zygo. The user is strongly urged to use the Zygo (operator) option.

2.6.3 Under “Motions”, click the button to home the stage.

2.6.4 Under file, load applications. The one to load is Micro.appx. Proceed, following the steps in Section 2.7.

2.7 Use of Calibration/Validation Tools

There are lateral and vertical calibration/validation standards that came with the interferometer. The lateral standard was used after installation to calibrate the lateral resolution of the instrument and does not require further use. On the other hand, the vertical step height standard must be used for calibration purposes on any sample where a quality-affecting measurement is being made. If the user is simply interested in imaging the surface of a sample, without making quantitative measurements, then the user does not need to use the vertical step height standard. On the other hand, if the user desires to make quantitative measurements of height measurements on the sample surface, then the use of the vertical standard is warranted and should be used daily before attempting to obtain measurements. Use of the standard will ensure that accurate vertical height measurements will be made and that an uncertainty on that measurement can be quantified.

The vertical or “step-height” standard consists of quartz plate in which a trough has been precision milled down the middle of the plate. The depth of this trough, 1.767 μm, is certified and measurements against this depth will be made by the interferometer. Acceptable deviations from this value are ±0.011 micrometers (although in practice the measurements tend to vary on the order of ±4 nanometers). The step-height standard is located in the drawer in the desk on which the computer monitor rests. (Please take care when removing the lid of the box holding the standard. The lid is very tightly held by the base and too much force may result in sudden separation and the possibility of dropping the standard and causing damage).

Note that the step-height standard is chrome-plated, therefore, make sure to place the standard right-side up. Placing it upside down may result in damage to the standard. If it is not clear which side

this is, ask someone who is more experienced for help. The procedure for determining the height uncertainty is listed in steps 2.7.1 thru 2.7.8.

2.7.1 Using the 10X objective with the 0.5 zoom (thus, 5X magnification in total), focus on the slide and adjust the light by clicking on “Focus aid” and “Auto LL” buttons while in the “Measurement” tab. Make sure that the trough is oriented straight (“north-south”) on the stage. See Section 2.5 Instrument Operation for more details on focusing the standard.

2.7.2 In the “Measure” tab, click the “Measure” button (blue icon in the upper right-hand side) to obtain an image.

2.7.3 Click on the “Analysis” tab, and click on “Regions” on the navigation bar on the left-hand side.

2.7.4 Click the “Segmentation On” box. The dialogue box will then be activated (going from grey to black). On the left-hand side of the box, under “Segmentation Options”, go to “Segmentation Mode” and from the drop-down box, go to “Masks”.

2.7.5 Under “Masks”, click the “Configure Masks” box and a dialogue box will appear.

2.7.6 Drag a rectangle into the trough area, and then exit by clicking ‘x’ on the far upper right-hand side of the dialogue box. (It is recommended that there should be a little space between the edges of the drawn box and the edges of the trough).

2.7.7 On the right-hand side, on “Reference” go to “Define By” and choose “Mask” from the drop down menu. Click the “Configure Reference” in this dialogue box and drag rectangles to higher portions adjacent to the trough on either side. A box within the dialogue box (called the “Shape Properties”) will become active when the user is placing the rectangle.

2.7.8 Go to the “Measure” tab to make a measurement. There is a box on the lower left-hand side in which the option for making multiple measurements can be exercised. Make 10 measurements and record the average height difference. This value will constitute the uncertainty on the vertical height measurement.

2.7.9 The calibration value will be documented in the scientific notebook and a successful calibration will be noted by stating that it passed the acceptance criteria (the value must be 1.767±0.011 μm to be acceptable).

2.8 Interferometer Maintenance

There are no maintenance issues associated with this instrument.

2.9 Shutdown of Interferometer

The system can be left in the “on” position (the long-lasting LED light is rated for years), or one can choose “Exit” from the “File” menu.

2.10 User Manual

A PDF version of the User Manual is located on the “desktop” of the computer.

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

Not Applicable. There are no appendices in this SP.

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