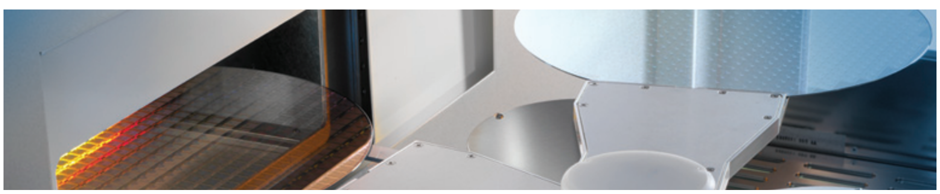

Alpha-Step® D-500 and D-600 User Manual

9019320-000

Revision AC

KLA-Tencor Confidential—Restricted Distribution

Alpha-Step® D-500 and D-600 User Manual

KLA-Tencor Corporation

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KLA-Tencor Document Number: 9019320-000

Revision: AC

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Safety

Contents

1.1 Introduction

This section contains the safety information related to using software.

1.2 Safety Notice

WARNING

The exclamation point with an equilateral triangle is intended to alert the user to the presence of important operation and servicing instructions in the literature accompanying the product.

Laser Safety

This unit employs an embedded Class IIIa diode laser. Only qualified persons should remove the cover or attempt to service this unit due to the risk of eye injury. If the unit is opened and the laser beam is directly accessed do not stare into the beam or view directly with optical instruments.

Laser Properties

Type: Diode Laser

Wavelength: 635 nm

Laser Output: Constant Wave 5 mW max.

2

Introduction

Contents

2.1 Introduction

This manual describes in detail the operation of the Alpha-Step Development Series Stylus Profiler. This manual is intended as a tutorial and reference for individuals who use the Alpha-Step D-500 or Alpha-Step D-600 profiler systems to inspect and analyze sample surfaces, and as a general guide to configuration and maintenance of the instrument.

- "How to Use this Guide" on page 4
- "Instrument Overview" on page 5
- "Features and Options" on page 6

2.2 How to Use this Guide

It is assumed throughout this manual that the user has a general understanding of using personal computers, operating in a Windows environment, using a standard mouse and keyboard, and understands basic Windows Operating system conventions.

To get the most out of this manual, first-time users should proceed sequentially through the following chapters to get an overview of the instrument and its operation:

Chapter 2, Introduction discusses how to use the manual, terminology used, and an overview of the instrument and its features.

Chapter 3, Setting up the Instrument details the procedures necessary for installation of the instrument and the proper procedure for packing the instrument for moving or shipping.

Chapter 4, Description of Features provides information on starting the instrument and a description and overview of the controls and features.

Chapter 5, Basic Operation describes how to use the instrument and walks the user through making a measurement.

Chapter 6, Working with 2D Profiles provides a description of the analysis features and how to use them on profile data.

Chapter 7, Advanced Features provides a description of the advanced software features available to the user such as, 3D scanning, Stitching, Sequence Scanning, Histogram, and multiple profiles.

Chapter 8, Apex2D/3D - Getting Started provides information about configuring Apex 2D/3D to work with the Alpha-Step system.

Chapter 9, Thin Film Stress Module provides information about the use of the Wafer Stress software option for analysis of thin film stress.

Chapter 10, System Maintenance discusses the Alpha-Step Development Series service policy, troubleshooting, and changing the stylus.

Appendixes listing the Alpha-Step Development Series of instruments Specifications and **Options and Accessories** are also provided at the end of this manual.

2.3 Instrument Overview

The KLA-Tencor **Alpha-Step Development Series** Stylus Profiler is a computerized, high-sensitivity surface profiler that measures step height, roughness and waviness in a variety of applications. It features the ability to measure precision step heights from under 10 angstroms to as large as 1.2 mm. The profiler incorporates a new optical deflection height measurement mechanism and magneto static force control system that results in a low force (loads as small as 0.03 mg) and low inertia stylus assembly, making it the most innovative bench top profiler on the market today.

These innovations combine to produce a surface profiler capable of measuring soft films and substrates without surface damage. The Alpha-Step Development Series profiler provides an affordable, high-resolution surface measurement capability that nicely complements other analytical instruments. A complete listing of specifications and features can be found in Appendix A, “Profiler Specifications”.

The instrument is available in two hardware configurations: Alpha-Step D-500 manual stage and the Alpha-Step D-600 with motorized stage controls up to 150 mm travel.

The Alpha-Step Development Series profiler provides the following features:

- Measurement of vertical features ranges from under 10Å to over 1 mm with a vertical resolution better than 1Å for the 2.5 µm range setting and 100nm resolution for the 1.2 mm range setting. Measurements can be taken in metric or English units, which are selectable independently for horizontal and vertical parameters.
- Up to 400,000 data points per profile guarantees that the horizontal resolution is generally limited by the stylus radius and not the number of data points.

- Measurement of many roughness and waviness parameters with the roughness and waviness separated by user-selectable cutoff filters.
- Motorized positioning of the sample surface to within 0.5 microns in X-Y using the Alpha-Step D-600 configuration.
- Many easy to use features, including software adjustable force control, intuitive user interface, easy mouse control of measurement cursors and stage position.
- Accommodates samples over 200 mm in diameter and heights up to 30 mm.
- 3D Rendering advanced analysis package extends the measurement capabilities of the Alpha-Step D-600 platform without optional hardware requirements.

2.4 Features and Options

2.4.1 Hardware Features

Computer - An Intel processor running Windows 7 available to KLA-Tencor at the time of manufacturing. KLA-Tencor uses only vendors with worldwide service and technical support.

Monitor - 19 in. Flat Panel or equivalent display monitor accompanies the Alpha-Step Development Series systems.

Motor Controls - All system controls are accomplished with the computer keyboard and mouse. No special control hardware is necessary.

KLA-Tencor Measurement Head - All Alpha-Step Development Series systems come standard with the low force frictionless pivot stylus head and a force control feedback system. The force control and frictionless pivot permit accurate profiling of the surface topography with minimal stylus contact force. The stylus arm has a minimal moment of inertia, so it is much less susceptible to environmental noise.

The measurement head incorporates a video camera imaging system that allows the user to accurately position the sample under the stylus. The Alpha-Step Development Series systems includes a 1x -4x digital zoom.

Vacuum Sample Hold-Down - The vacuum hold-down enables a sample to be held securely in the center of the stage and is available with the Alpha-Step D-500 and D-600 systems.

2.4.2 Software Features and Options

Operating System - The Alpha-Step Development Series Systems use the Windows 7 operating system.

Alpha-Step Development Series Software Interface – KLA-Tencor uses standard Windows graphical user interface conventions and drop-down lists to navigate and control the software functions. All system functions can be accessed by using the mouse or keyboard controls to navigate the drop-down lists.

Data Analysis Features - The Alpha-Step Development Series software comes standard with calculations for many popular parameters, refer to Chapter 4, “Description of Features,” on page 23 for specific definitions of the parameters calculated.

Thin Film Stress Option - The Thin Film Stress Option calculates the stress levels in a deposited film by measuring the deflection or curvature that the stress induces in the substrate, (refer to Chapter 9, “Thin Film Stress Module,” on page 143).

Precision Locator for Thin Film Stress Option - A universal stress chuck is available to enable exact positioning of a sample relative to a fixed reference, flat or notch. The chuck allows various positions for the locating pins and standoffs to accommodate wafers from 50 mm to 200 mm. Call KLA-Tencor Customer Support for more information.

Sequence Feature - Sequence software allows the user to program the stage for multiple measurements, test patterns, or set a routine to collect multiple profiles for 2-D rendering. The user can save Sequence Files and correlate them with Scan Recipes to enhance the instruments repeatability and ease of use (refer to Chapter 7, “Advanced Features,” on page 117) for a detailed description of the features.

3D and Advanced Analysis Software - The 3D and advanced analysis option expands the capabilities of the Alpha-Step Development Series instrument. The software allows the user to render 3D images of the sample surfaces. It provides a suite of leveling and form removal utilities, profile extraction from any angle in a 2-D or 3-D image, particle and grain analysis, FFT and advanced filtering, batch processing of data, and report writing capabilities. This option is available only on the Alpha-Step D-600 system.

Stitch Feature - The Stitch feature allows the user to extend the usable profile scan length. The stitching function in the sequence recipe enables the user to combine up to 10 profiles with user defined overlap to make a long profile. The stitched profile is available right after the sequence scan finishes. Another independent stitching feature can combine up to 5 profiles end to end to make a long profile. The independent stitching function needs the user to manually combine the pre-saved profiles.

3

Setting Up the System

Contents

3.1 Location Considerations

The stylus profiler is a delicate instrument. It is sensitive to vibrations, acoustical noise, air currents and temperature changes. Successful results with your instrument depends on the extent to which it is isolated from these environmental effects.

3.1.1 Facility Specifications

Power

Four standard AC outlets (110 V, 5A, 60Hz in the USA STANDARD and 220 V, 5A, 50Hz in other parts of the world option). Even if the power source is known to be clean and reliable, a surge protector is recommended. If power failure is a common occurrence, use an Uninterruptible Power Supply (UPS) device. A UPS device supplies power for 30 minutes so that an orderly shutdown can be performed.

Vacuum

Software on/off control:0.125 in. nominal line providing a minimum of –250 mm Hg at a flow rate of 0.236 l/s. A vacuum pump can be ordered as an option with the instrument if sufficient house vacuum is not available.

Dimensions

Alpha-Step D-500: 10 in. Wide x 16 in. Deep x 10 in. High

Alpha-Step D-600: 15 in. Wide x 24 in. Deep x 13 in. High

Ambient Temperature

Specified operating range: 70° ± 9°F (21° ± 5°C); Max. operating range: 70° ± 20°F (21° ± 11°C). For best accuracy: 2° F maximum change/hour Storage: 0° to 115°F (-18° to 45°C).

Environment

Floor vibration (from 2-40 Hz) should be less than 0.2 mG (G= gravitational force of approximately 32 ft/s2 or 9.8 m/s2). Acoustic noise should be less than 80dB.

3.1.2 Vibration and Noise

If possible, place the profiler on the ground floor or basement level to minimize building vibrations. The pivot assembly is the sensitive portion of the instrument. The **Alpha-Step Development Series** profiler comes with internal shock/isolator mounts built into the base of the instrument ensuring a basic level of isolation.

For optimum performance, provide a rigid, sturdy table that can support 100 lb or more and is large enough to accommodate the size of the **Alpha-Step Development Series** profiler. There should also be sufficient room beneath the table for a computer. The monitor, keyboard and mouse should be placed near the instrument on a separate surface.

It is always recommended that the instrument be mounted on an isolation table or heavy granite slab that is isolated from floor vibration for highly sensitive measurements (that is, artifacts less than 500 to 1000 angstroms or in noisy areas).

3.1.3 Air Currents and Temperature Fluctuation

All the **Alpha-Step Development Series** profiler instruments have covers to reduce the effects of air currents during a measurement. It is suggested to locate the instruments away from any type of air flow to get best performance. It is best to place the instrument in a room where a relatively constant temperature is maintained to minimize long-term temperature-dependent effects on the measurement.

3.1.4 AV Table Option

KLA-Tencor supplies, as an option, a simple and inexpensive means of isolating your **Alpha-Step Development Series** profiler from mechanical vibrations— the AV table is a stand alone closed air system that reduces vibration affecting the instrument. The AV is a desktop floating air table that is slightly larger than the instrument footprint.

3.2 Unpacking

Retain all packing material and report any obvious damage caused by improper handling to the shipping company. Contact KLA-Tencor for assistance in filing a claim against the shipping company if any components of the **Alpha-Step Development Series** profiler have been damaged in transit.

The **Alpha-Step Development Series** profiler is shipped assembled in a crate. The number of boxes varies depending on the exact equipment (options) ordered.

Computers are shipped in the computer manufacturer shipping containers. Unless special requests have been made, all software to be supplied by the computer manufacturer, with the addition of the **Alpha-Step Development Series** profiler software to control the instrument.

The Alpha-Step D-500 weighs about 30 lb; the Alpha-Step D-600 profiler weighs about 90 lb. It is suggested that two people remove the instrument.

3.2.1 Shipping Contents

Check that all components listed in the enclosed System Components List are included in the shipped containers and match the Packing List. Remove all the components from their shipping containers and save all packing materials and documentation in the event the instrument needs to be moved or shipped back to the KLA-Tencor factory. The following items are shipped with the basic system:

One **Alpha-Step Development Series** profiler Backup Software CD-ROM

One **Stylus 2.0 µm** (installed), unless otherwise specified in the order

Three AC power cords

Vacuum Adapter (Alpha-Step D-600 profiler systems only)

One USB cable

Computer with keyboard, mouse, and Software disks

Flat Panel Display monitor or equivalent

3.3 Pre-power Preparations

The **Alpha-Step Development Series** profiler system is wrapped in plastic and then placed inside the shipping crate. This plastic wrapping is intended to keep the shipped instrument clean from exposure to the packing material prior to installation. If the instrument is being installed in a clean room environment do not remove the plastic wrap before entering the gowning area of the clean room where the installation occurs.

The following unpacking instructions assume the **Alpha-Step Development Series** profiler system to be installed in a clean room environment:

1. Inspect the boxes and crate for any signs of damage or mishandling.
2. Inspect the Tiltwatch™ and Shockwatch™ stickers on the outside of the crate. If the sensor indicates mishandling, contact KLA-Tencor immediately and do not unpack the system further until confirming with KLA-Tencor service department.
3. Use a wrench or socket ratchet to remove the bolts from the four sides of the crate.
4. Lift the crate top from the base by lifting straight up (for Alpha-Step D-600 use two people to ensure that the instrument is not hit while removing the lid) and place aside.
5. Carefully lift the instrument off the foam base of the crate and place on a cart appropriate for the weight of the instrument (specified for more than 150 lb and clean room compatible).
6. Unpack the computer and monitor from their boxes and leave them in their respective plastic bag covers in preparation for placement into the clean room.
7. Move the system into the gowning area of the clean room.
8. Remove the plastic bag covers from the computer, monitor and **Alpha-Step Development Series** profiler system.
9. Carefully place the **Alpha-Step Development Series** profiler system on a sturdy floor mounted bench, or for better results, a vibration isolation table. (For more information regarding recommended vibration isolation tables contact KLA-Tencor Customer Service.)
10. Gently peel back the tape from the windscreen of the Alpha-Step **Development Series** profiler cover, and gently remove the restraining tape from the stage. The stage is held in position with a block at the front of the stage, ensure to remove the packing block and save this with the original packing material.

NOTE

Apply light pressure to the stage when removing the tape to prevent the stage from lifting from the optical flat.

11. Locate the computer on the floor or near the **Alpha-Step Development Series** profiler instrument ensuring that the cables are not stretched taught, but hang loosely from the back of the instrument to the computer and monitor.
12. Locate the monitor, keyboard, and mouse on the bench top above or next to the computer and profiler.
13. Store the shipping crate and boxes in a dry accessible place. In the unlikely event that the instrument needs to be returned to the factory, it must be shipped in its original container.

3.4 Cable Connections

The back panel of the **Alpha-Step D-600** profiler has three connections. The Alpha-Step D-500 only has two connections, it does not have a vacuum connection.

Power - Standard IEC-320 terminated UL-Listed computer. The voltage is set at the KLA-Tencor factory.

USB - The **Alpha-Step Development Series** instrument uses a Standard A to B USB cable to connect the instrument to the PC controller and Alpha-Step Development Series profiler software. All Alpha-Step Development Series profiler instruments use USB connection for the video. One connection plugs into a computer USB port and the other connects into the **Alpha-Step Development Series** profiler back panel USB port as shown in Figure 3-1 and Figure 3-2.

Vacuum -The connection to the back of the instrument is a 1/4” OD flexible tubing (included). The vacuum pump needs to be supplied by the customer. The vacuum pump input port connection depends on the pump provided.

3.5 Cable Hook-up Instructions

Figure 3-1 Cable Hook Up Instructions

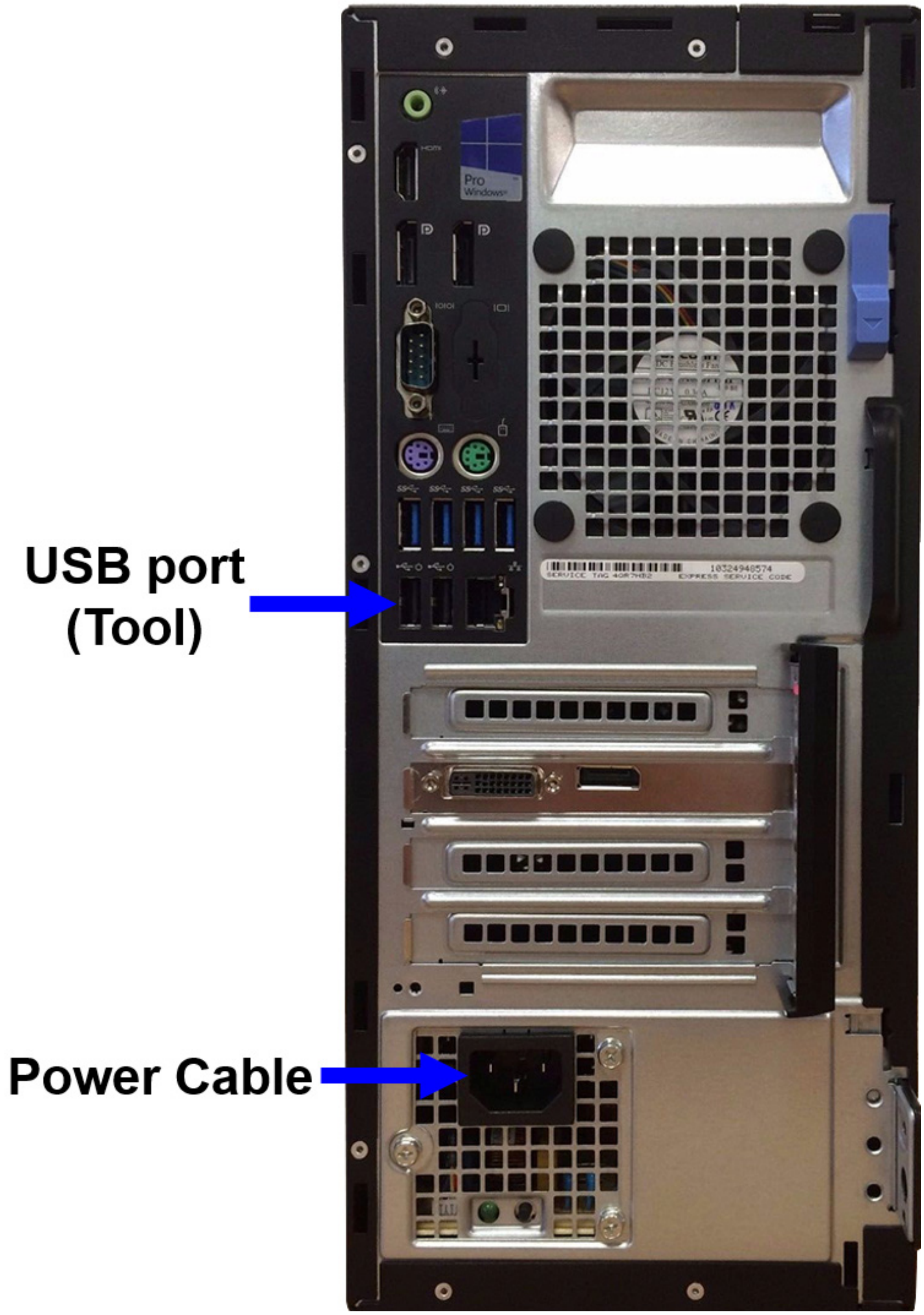
Follow the Computer manufacturer's setup procedures to properly hookup the monitor, keyboard, mouse and other hardware such as printer, Ethernet, and many more.

Connect the cables for the **Alpha-Step Development Series** profiler instrument to the computer (see Figure 3-2 for back panel connector layout). The USB port for the profiler is labeled with Tool in the cak panel of the computer.

NOTE

If the USB cable is plugged into the wrong USB port, the computer asks the user to install the proper driver. Do not continue the stop, reconnect the USB cables to their proper port.

Figure 3-2 Computer Back Panel with Cable Connections



3.6 Final Inspection

1. Check that all the shipping restraints and stage block have been removed (see Figure 3-4 and Figure 3-5 for details).
2. Check that the power, USB, and vacuum (if needed) are connected properly and securely.

NOTE

Inspect that the cables are not stretched taut between the computer and **Alpha-Step Development Series** profiler instrument as this affects the proper functioning of the instrument and cause noise which can affect your measurements. If you are using a vibration isolation table, stretched cables limit the effectiveness of the isolation table to operate as specified.

If a vibration isolation table is being used:

1. Check to ensure the tabletop is free to move in all directions.
2. Check to ensure the cables in the back of the instrument have a sufficiently large service loop to ensure minimal vibration is transmitted through the cables to the isolation table.

NOTE

KLA-Tencor Warranty Policy does not cover damage to the stylus, the stylus arm assembly, or the pivot caused by operator error or carelessness.

3.7 Powering up the System

The following procedure applies to new instruments:

1. Turn on the AC power to the computer (located on the front panel of the computer) and monitor.

NOTE

Allow the computer to startup completely before proceeding with the next step.

2. Turn on the AC power to the **Alpha-Step Development Series** profiler instrument (located on the back panel of the instrument).

NOTE

Wait 10 seconds before proceeding to the next step in order to allow the USB communications to establish a connection.

To start the **Alpha-Step Development Series** profiler software, double-click the **Alpha-Step Development Series** software icon located on the computer desktop. Then, **Home All Stages** is displayed automatically and the system is ready to use.

3.8 Shipping

If the instrument needs to be returned to the factory or moved to another location, follow the shipping preparation instructions as follows:

Before powering down the system:

1. Disconnect the vacuum line from the back panel of the instrument.
2. Raise the measurement head to its upper limit.
3. Move the stage to its Home stage position (Applies to the Alpha-Step D-600 system only).
4. Quit the **Alpha-Step Development Series** profiler software.
5. Shut down the computer using proper Microsoft Windows procedure.
6. Install the stage block as shown in Figure 3-3. Slide the block between the stage and front panel until it is snug (the stage block for the **Alpha-Step D-500** model is smaller than shown in Figure 3-3).

Figure 3-3 Stage Block Protects the Scan

NOTE

The protective block should be removed before starting up the instrument. Do not tap down on the block.

7. Restrain the stage and block using threaded fiberglass tape along the Y direction of the stage as shown in Figure 3-4.
8. Restrain the stage using two strips of threaded fiberglass tape along the X direction as shown in Figure 3-4 (For the Alpha-Step D-500 stage it might be necessary to use one tape strip across the stage to secure it).
9. Close the stage door cover, making sure that the cover clears the block between the stage and front cover.
10. Restrain the door cover using two strips of threaded fiberglass tape as shown in Figure 3-5.
11. Cover the instrument in a plastic bag to keep it clean from the packing material.

Figure 3-4 Stage Restraints

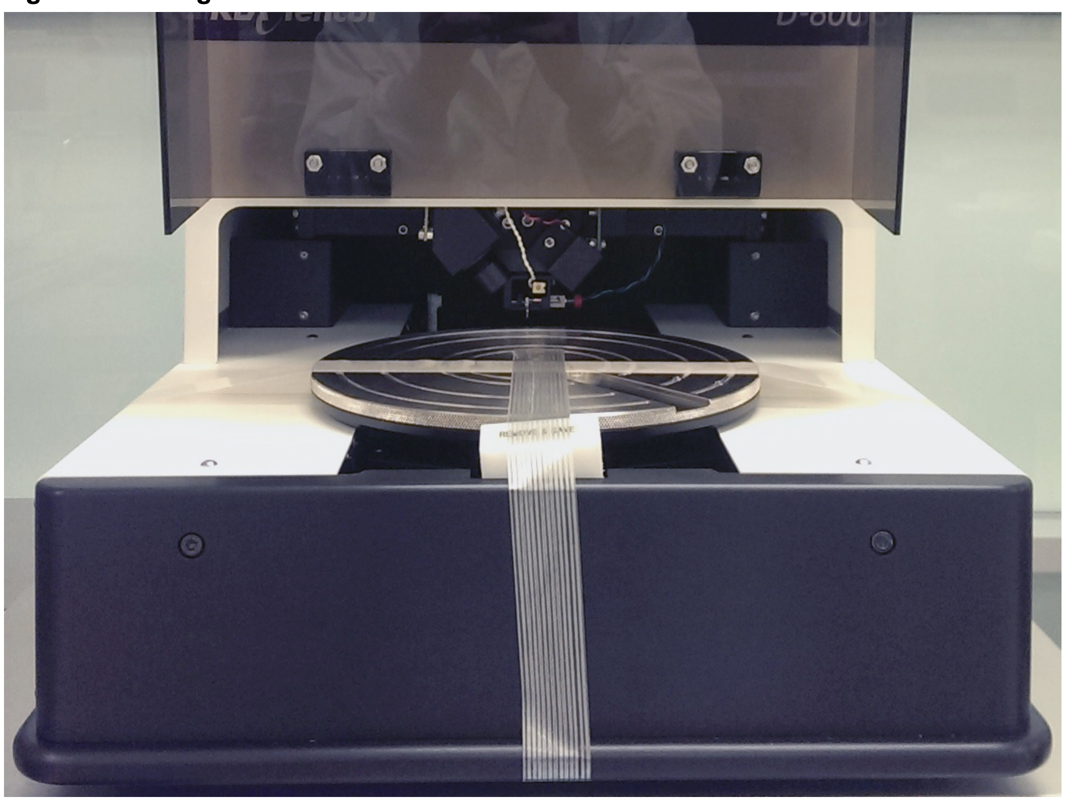


Figure 3-4 shows one vertical strap holding the stage and block, and two straps along the horizontal direction each approximately 3/4 in. from the center of the stage.

12. Place the **Alpha-Step Development Series** instrument on the bottom foam pad of the shipping crate. Center the instrument on the foam.
13. Slide the Crate cover over the base of the crate.

Figure 3-5 Fiberglass Threaded Tape Holding

Figure 3-5 shows the stage cover door closed over the block restraint coming out from under the stage cover door.

LIFT WITH TWO PERSONS

Use two people to hold the crate cover and slide it straight down over the instrument to refrain from hitting or damaging the system.

14. Tighten the eight bolts on all four sides using a ratchet or wrench.
15. Package the computer and monitor in their original boxes.
16. The system is ready to move to a new location or ship back to KLA-Tencor.

4

Description of Features

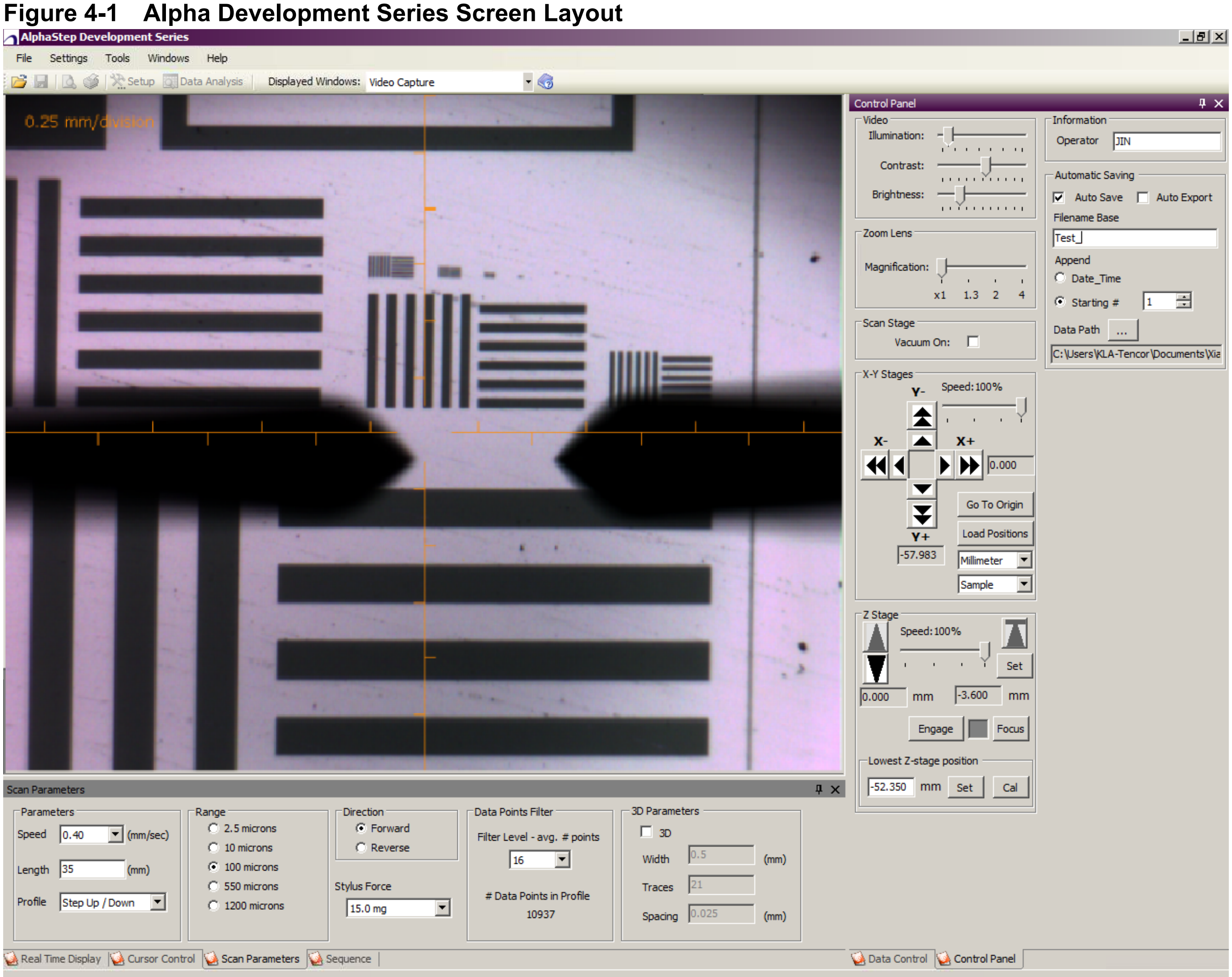
Contents

4.1 Introduction

This chapter gives a description of the instrument, software features and screen layout. Each of the features is defined, and where appropriate, reference to more detailed operation instructions is provided for the reader to learn more about that particular feature. Additionally, there is a description of the measurement head and pivot assembly.

4.2 Screen Layout

Figure 4-1 Alpha Development Series Screen Layout



4.2.1 General Description

The **Alpha-Step Development Series** profiler application organizes functions in Windows and Tabs. Windows are used for the video camera view and data display. Windows can be resized, ordered or stacked, depending on the user preference. Tabs are generally used for controls. Tab controls as a default are docked into a set position. The Tabs can also be set to float and behave like a Window. If the user changes their mind they can return a floating tab to its default docking position. The user can have all the major functions of the software available in a single view or stacked in open windows or arranged in any order and size convenient to the operator. The features of the **Alpha-Step Development Series** profiler Software Application are explained in the following.

NOTE

Some controls might be disabled at times, depending on the mode of operation of the instrument.

1. **Application** Drop-down lists are always shown at the top of the Application Window. These menus are accessible any time by using the cursor to choose one of the drop-down items. If a selection is disabled it is not available.
2. **Application** Tool Bar is always displayed in the Main Application Window. The user cannot add or remove buttons to this tool bar. A list of the features and their description is given in the following.
3. **Video Capture** window displays the video view from the CCD camera located on the measurement head. The default is for the Video Capture Window to open when the application is opened.
4. **Scan Parameter Control** tab by default is docked at the bottom of the **Alpha-Step Development Series** profiler Application Window. This control tab displays the scan parameters. A more detailed description is given in “Scan Parameter Tab” on page 42.
5. **Control Panel** tab by default is docked to the right side of the application window. This control tab displays all of the stage controls for the video

display, video zoom, vacuum, X-Y stage motion and Z stage motion. A more detailed description is given in “Control Panel Tab” on page 62.

6. Other Control Tabs:

   Sequence tab is available only for the D-600. This tab sets the scan recipe of sequence scans.

   Cursor Control tab is displayed when the Data Window is opened. This tab has controls to adjust the cursor position and width. It also displays the High Pass and Low Pass filter settings.

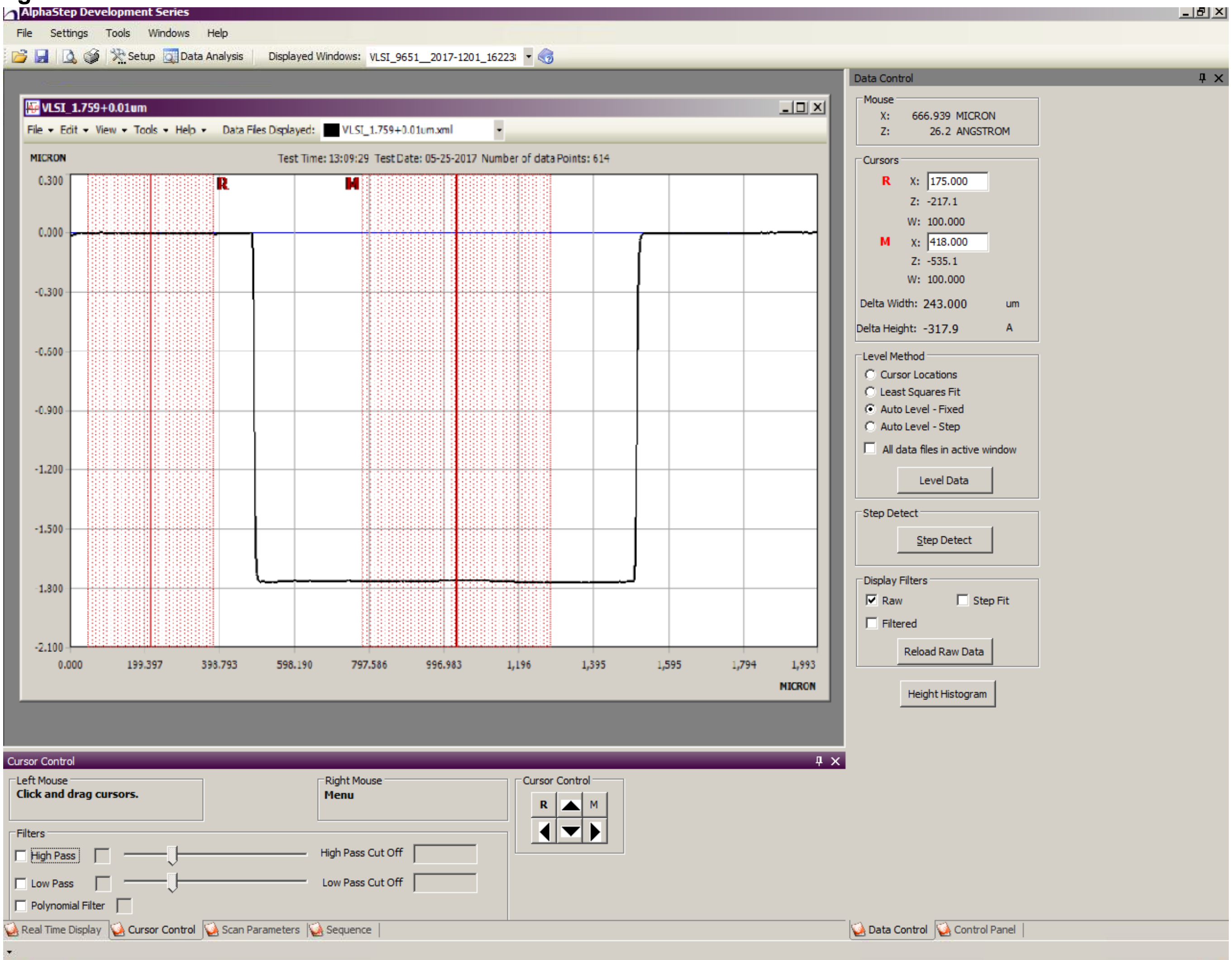
   Real Time Display (RTD) tab displays the profile in real-time as the stylus is moving across the sample surface. The RTD allows the operator to view the profile as it is being taken. It gives the user a rough idea if the scan is level and in the range of the measurement or needs to be aborted and restarted after making an adjustment.

   Data Control tab is displayed when the Data Window is opened. This tab displays the cursor location, the leveling features, the Step Detect button, and Histogram button.

7. **Data** window is opened only after a profile scan is completed or the user loads a previous scan into the application.

8. **Data Analysis** tab is available only after the user selects parameters from the Calculations Window and then selects to calculate results. The Data Analysis can show results from a single Data Window or from all open Data Windows.

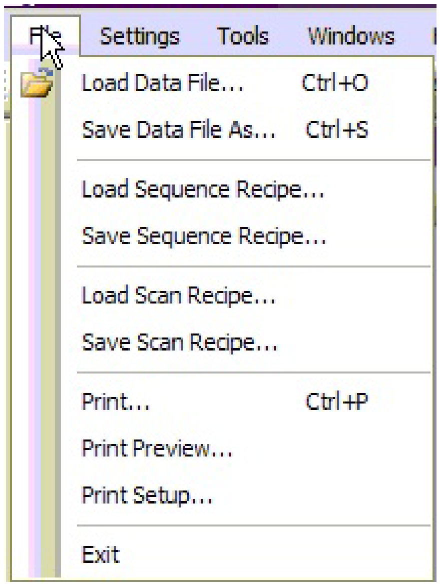
Figure 4-2 Data Window



4.2.2 Alpha-Step Development Series Application Drop-Down Lists

The **Alpha-Step Development Series** profiler Application drop-down lists in general are features that apply to all Windows that are open in the case that multiple Data Windows are displayed. If a drop-down list lists an item that is disabled this means the function is not available at that time and requires either a loaded profile to be available or a setting to activated. A description of the drop-down lists is given in the followings.

Figure 4-3 File Drop-Down List

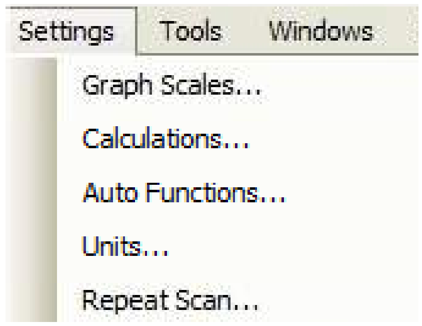


File Drop-Down List

- **Load Data File** - This opens the Data Folder. Saved profiles can be loaded into the **Alpha-Step Development Series** profiler software for further analysis. Choose a filename to load the profile data. The profile is then viewed by opening the Data Display window.
- **Save Data File** - This opens the standard Windows save file dialog box. Choose a filename to save the current profile data. The profile is then saved in the folder selected.
- **Load Sequence Recipe** - This button opens the standard windows and asks the user to open a saved sequence recipe. The Sequence Control Pane uses the parameters of the loaded recipe. The user can also load the sequence recipe from the Sequence Control Pane as in Chapter 7, “Advanced Features,” on page 117.
- **Save Sequence Recipe** - This button prompts the user to name and save the current sequence recipe. The user can also save the sequence recipe from the Sequence Control Pane as described in Chapter 7, “Advanced Features,” on page 117.
- **Load Scan Recipe** - This opens a dialog box and the user can load a pre-saved 2-D or 3-D scan recipe.
- **Save Scan Recipe** - This opens a dialog box and asks the user to name and save the current scan recipe.
- **Print** – This opens the standard **dialog** box prompting the user to choose a printer and the printer set up.
- **Print Preview** – This opens a standard Windows preview window that displays the current profile data as it would look for printout.

- **Print Set-up** – This opens a standard Windows Printer Set-up Window that allows the user to choose the printer settings before printout.
- **Exit** – This quit the **Alpha-Step Development Series** profiler software (this does not shut down the computer).

Figure 4-4 Settings Drop-Down List



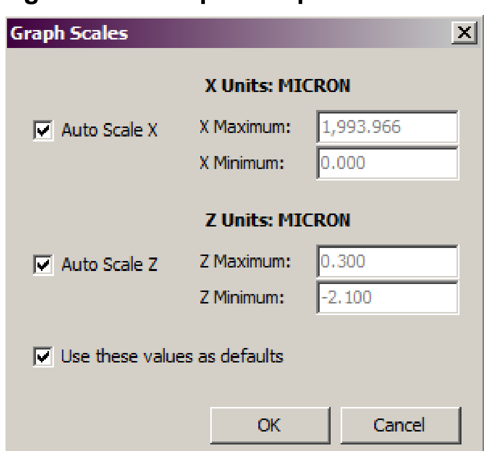
Settings Drop-Down List

- Graph Scales – This opens the control window for the graph parameters for data displayed in the Data Display window.

Auto Scale X – This check box displays the full length of the profile X data in the Data Display window when the box is checked. If the box is not checked, the X data is displayed in the range entered into the X Maximum and X Minimum text boxes.

X Maximum – This value is the upper limit that the X data is displayed in the Data Display window.

Figure 4-5 Graph Setup window



X Minimum - This value is the lower limit that the X data is displayed in the Data Display window.

Auto Scale Z - This check box displays the full range of the profile Z data in the Data Display window when the box is checked. The data is rescaled after leveling or zooming. If the box is not checked the Z data is displayed in the range entered into the Z Maximum and Z Minimum text boxes.

Z Maximum - This value is the upper limit that the Z data is displayed in the Data Display window.

Z Minimum - This value is the lower limit that the Z data is displayed in the Data Display window.

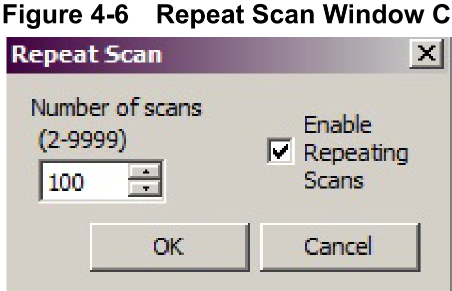
- Calculations - This opens the Setup window to the **Calculation** tab. For more information on choosing the calculation parameters, refer to “Calculation Settings” on page 45.
- Auto Functions - This opens the Setup window to the **Auto Functions** tab. For more information on choosing the calculation parameters, refer to “Auto Functions” on page 49.
- Units - This opens the Units Window in which the user can change the scan display units in either metric or English units. The scale controls allow the X-Y scaling to be set separately from the Z scale.

English/Metric - The user can select to display the data in either English units or Metric units. The X Data Units and Z Data Units choices are displayed accordingly.

X Data Units – Select the radio button for the units in which the X data is displayed in the Data Display window.

Z Data Units - Select the radio button for the units in which the Z data is displayed in the Data Display window.

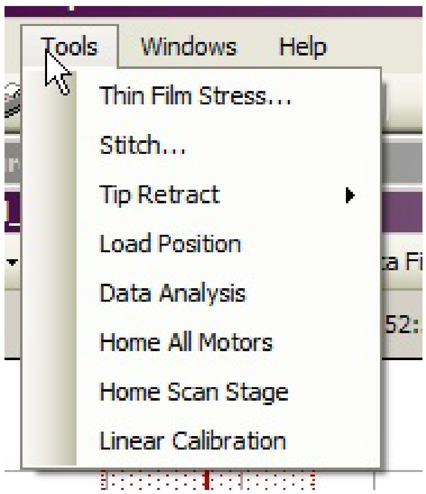
Figure 4-6 Repeat Scan Window Control



- Repeat Scans – This opens a Window to control the auto save and naming default for profile data. This feature allows the user to select a root name for scanned profiles that is automatically saved to a folder and named in numerical order.
- Number of Scans – This field sets the number of scans that is repeated in the same location when the user activates this feature and then starts a scan.

- Enable – This check box turns the feature on and off. It is off when empty and on when there is check mark in the box.
  - OK – This button closes the Window and accepts the values set before closing.
  - Cancel – This button closes the Window without accepting any changes made before closing.

Figure 4-7 Tools Drop-Down List



Tools Drop-Down List

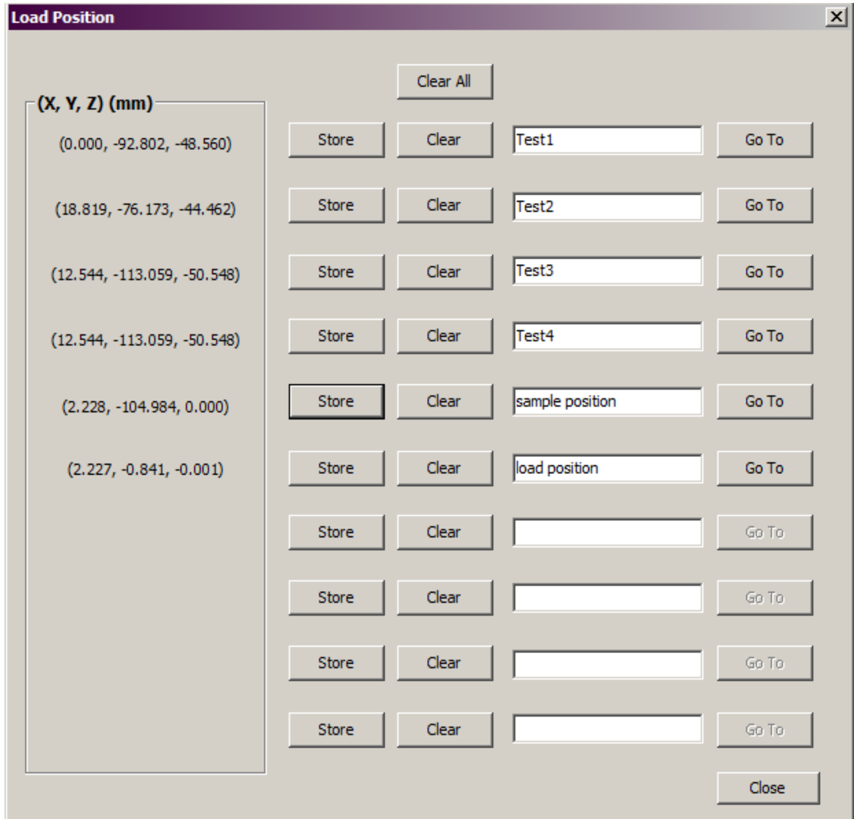
- Thin Film Stress - This opens the Thin Film Stress option window. For details on using Thin Film Stress, refer to "Chapter 9, "Using the Thin Film Stress Option," on page 147.
- Stitch – This opens the Stitch control panel. This panel allows the user to add multiple profiles together to make a single larger profile up to 400,000 data points. The profiles being added must have the same data point spacing though they do not need to have the same length. For details on using Stitch, refer to Chapter 7, "Advanced Features," on page 117.
- Tip Retract – This opens a menu that allows the user to choose from three predefined distances that the stylus is retracts from the sample surface after finishing a scan or by pressing the Home X-Y Stages or Load Positions buttons on the Main software screen.

  Short – The system moves the Z-stage away from the sample surface for 1 mm before stopping.

  Medium – The system moves the Z-stage away from the sample surface for 2 mm before stopping.

  Long - The system moves the Z-stage away from the sample surface for 3 mm before stopping.

Figure 4-8 Load Position Control Panel

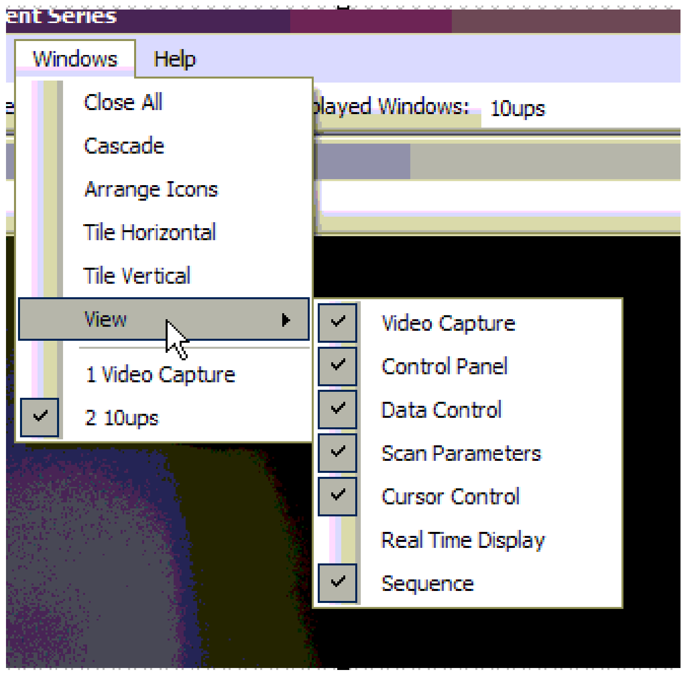


- Load Position – This opens the Load Position Control Panel. The user can save up to 10 stage locations each with a location heading. The user must enter a location name in the corresponding text box to save a stage location. The user can clear a stored location individually or all of the locations at one time.
  - Store – This button allows the user to save to memory a specific X-Y Stage location, Z Stage location, and corresponding location heading.
  - Clear – This button allows the user to clear the corresponding stage location and location heading from the software.
  - Go To – This button allows the user to move the X-Y Stage and Z Stage to a predefined stage location corresponding to the specific location heading. For safety concerns, the Z stage moves only if the set position is higher than the current Z stage position.
  - Clear All – This button allows the user to clear all the saved stage locations and location headings from the software.
  - Close – This button closes the Load Position Control Panel and returns the user to the Main software screen.
  - Home All Motors – This homes the Z stage and X-Y stage.

- Home Scan Stage – This brings the Scan stage to home position. The stylus raises up to the distance defined in tip retract
- Linear Calibration – This brings up the linear calibration window.
- Data Analysis – Opens the **Data Analysis** tab and displays calculation results from the selected parameters in the **Calculations** tab. For more description of the Data Analysis features, refer to Chapter 6, “Data Analysis,” on page 84.

Windows Drop-down List

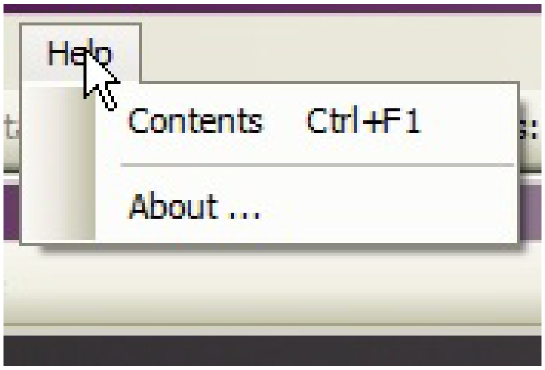
Figure 4-9 Windows Drop-Down Lists



- Close All – Closes all the open Data Windows inside the **Alpha-Step Development Series** profiler Application.
- Cascade – Arranges the open Windows overlapping each other one on top of the other with a small offset displaying the title bar.
- Tile Horizontally – Arranges the open Windows side by side and resizes them to fit the dimensions of the **Alpha-Step Development Series** profiler Application Window so that each one is equally visible.
- Tile Vertically - Arranges the open Windows along the vertical direction and re-sizes them to fit the dimensions of the **Alpha-Step Development Series** profiler Application Window so that each one is equally visible.
- View - This toggles on/off the visibility of the following panes, windows, or tabs: Video Capture window, Control pane, Data Control pane, Scan Parameters tab, Cursor Control tab, Real Time Display tab, and Sequence tab.

Help Drop-Down List

Figure 4-10 Help Drop-Down List



- Contents – This brings up the user manual PDF file.
- About – Opens the **Alpha-Step Development Series** profiler software splash screen showing the software version, log level and company information.

Applications Tool Bar Icons

Figure 4-11 Applications Tool Bar

- Open – Opens a new Data Window
- Save – Opens the **Save** dialog box so the current data displayed in the active. Data Window can be named and saved.
- Print Preview - Opens **Print Preview** Window of the active Data Window to show what the user sees when the page is printed.
- Print – Opens the Standard Windows Print controls allowing the user to select a printer and print settings.
- Set-up – Opens the **Alpha-Step Development Series** profiler calculation selection and Auto Step functions controls. This Window allows the user to make selections of the parameters for calculating results as well as the Auto Step settings. A more detailed description is given in Chapter 4, "Scan Parameter Tab," on page 42.
- Data Analysis – Calculates the parameters chosen in the **Calculations** tab of the Set-up Window on all the open Data Windows.
- Displayed Windows – Lists all the open Data Windows and including the Video Window. This drop-down list allows the user to select the active Window and move between different Windows.

4.3 Windows and Tab Features

The **Alpha-Step Development Series** profiler software use the individual Windows to organize the features and offer flexibility to the user. The controls for the use of the Windows and tab features are described in this section. There is no limitation to how many windows can be opened at the same time.

4.3.1 General Description

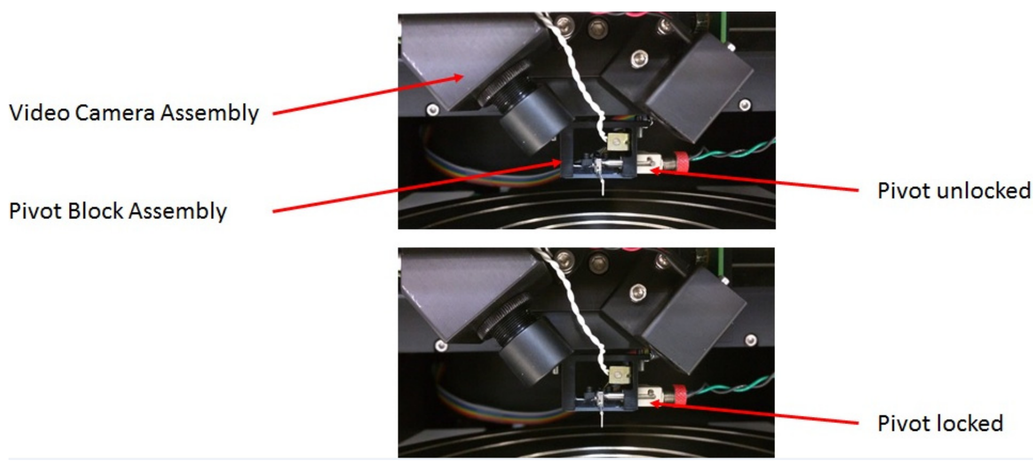
- Windows - Any Window that is floating in the **Alpha-Step Development Series** profiler application environment can be resized or moved by using the cursor to grab an edge or corner and then hold down the Left Mouse Button and drag that part of the Window to make it bigger or smaller.
- Tabs – Are as a default, anchored in the **Alpha-Step Development Series** profiler application environment. Each tab has a drop-down control in the upper right corner that shows available mode options for the tab. Any tab can have the following modes:
    - Float – This mode undocks the tab and sets it as a floating Window in the main **Alpha-Step Development Series** profiler application environment. If a tab is in Float mode, it has all the attributes described above for a window. To return a tab that is set to Float back to its original Docked position inside the **Application** window double-click the title bar of the Control window you wish to reset to a tab.
    - Dockable – Returns a Floating tab Window to its default Docked location.
- A tab can be closed by clicking the upper right corner of the tab or Window (when it is Floating). If a tab is closed, it can automatically be reopened if the user selects the associated function.

4.4 Measurement Head Hardware Description

The Measurement Head is the core of the **Alpha-Step Development Series** profiler. This part of the instrument enables high resolution and low force measurements. In addition to the measurement capabilities, the Measurement Head also incorporates important safety features and integrates them with the measurement hardware to make the **Alpha-Step Development Series** profiler easy to use, robust to user mistakes and easy to maintain.

The Measurement Head assembly is made up of two major sub-assemblies: The Pivot Assembly and the Video Camera Assembly. Each of these sub-assemblies is described in the followings.

Figure 4-12 Measurement Head Assembly



4.4.1 Video Camera Assembly

The video camera assembly uses a CCD camera array with an imaging lens. The camera is mounted at a 45 degree angle to the stylus so that the user can focus on the stylus tip as well as the sample surface to assist with sample positioning. The standard field of view is approximately 3.8 mm by 3.2 mm. The camera field of view can be changed using the software slider bar controls. Refer to Chapter 5, “Magnifying the Sample Image,” on page 68 for details on adjusting the camera zoom.

4.4.1.1 Pivot Block Assembly

The pivot block assembly is the heart of the profiler. This assembly includes the moving components that allow for the high precision and low force control profiling. The pivot assembly also incorporates an emergency sensor switch, break away stylus spring clamp, pivot lock, and laser adjustment screws.

Pivot Assembly Feature Descriptions

Laser position adjustment screws on each side of the pivot block assembly are the set screw adjustments (see Figure 4-12). The left side set screws adjusts the vertical laser position on the detector. The right side set screw adjusts the lateral laser position. The set screws are only used if the instrument requires service (call the KLA-Tencor Service Department for making any adjustments to the laser position).

- Pivot Clamp – The pivot clamp is a spring clamp design that allows for easy exchange of the stylus. All the styli have tapered D-shaped mounts so they self align when placed into the pivot clamp. The spring clamp design also allows for the stylus to break away from the clamp if the stylus is accidentally hit or the pivot fails and moves too far. This break away design ensures that the stylus is kept as safe as possible to reduce accidental damage requiring replacement of the stylus.
- Stylus Lock – The pivot and stylus can be locked using the spring loaded dowel post. The pivot lock is used when exchanging the stylus and for realigning the pivot assembly after service. Detailed instructions on using the pivot lock are given in the followings.
- Emergency Sensor Switch – The dowel post also serves as an emergency switch with the stylus clamp and pivot. The end of the dowel has a tapered end which sits inside the stylus clamp. If the pivot is accidentally moved too far up or down the dowel makes an electrical contact with the stylus clamp and stops the Z movement. This feature protects the stylus and pivot from accidental damage or crashing into the sample or the stage.

Locking the Pivot Assembly

1. Move the stylus to a safe distance above the stage or sample then gently grab the red knob on the right side of the pivot assembly (see Figure 4-12).
2. Gently press the red knob towards the left and turn clockwise until you feel the dowel lock into the new position.
3. Release the red knob, the pivot is now in the locked position and ready for stylus exchange.

Unlocking the Pivot Assembly

1. Move the stylus to a safe distance above the stage or sample then gently grab the red knob on the right side of the pivot assembly (see Figure 4-12).
2. Gently turn the red knob in a counterclockwise direction until you feel the dowel release from the locked position.
3. Allow the dowel to slide to the right into the unlocked position
4. Release the red knob, the pivot is now in the unlocked position and ready for scanning.

4.5 Protecting the Stylus Arm

The KLA-Tencor Warranty Policy does not cover damage to the stylus arm assembly or the pivot caused by operator error.

Although KLA-Tencor has made design precautions to guard against damage to the stylus arm assembly; there are cases where damage can occur. Damage can occur from the stylus hitting an object fixed to the stage that moves against the stylus shaft.

Specifically, the stylus can be damaged whenever it encounters an obstacle higher than the bevel height of the stylus tip that is higher than 0.4 mm. In addition, a shorter object can damage the stylus if it has sharp corners or burs that bite into the stylus tip.

The following cases illustrate ways in which you could damage the stylus arm assembly:

If you lower the stylus or start a scan when the sample is not directly under the stylus, damage to the stylus can occur by the stage moving the sample into the stylus from the side.

NOTE

Do not start a scan or move the stage unless you know that the stylus is directly over the sample or you could damage the stylus.

If the stylus is down and you move the stage without monitoring the video image, the stylus can hit the edge of an obstruction or precision locator and sheer the tip off.

NOTE

If the stylus is down, do not move the stage without monitoring the video image or you can damage the stylus.

If you change the substrate or precision locator without resetting the height of the stylus, the tip can run into the sample when positioning the sample under the measurement head causing damage to occur. The measurement head must be at least 6.4 mm above the top of the precision locator.

NOTE

The stylus drops about 4 mm (165 mils) less than the measurement head.

NOTE

If you change the substrate or precision locator to a different height, reset the height of the stylus position. Otherwise, you can damage the stylus and measurement head.

NOTE

When designing custom jigs or fixtures, consider the precautions noted in this section. For instance, when designing a custom disk locator, its center section must be flush with the top of the disk surface. Damage can also occur when there is a hole in a jig, a vacuum hole, or a groove in a surface.

4.6 Measurement Capabilities

It is useful to present information about the instrument capabilities so that the user can understand the abilities and limitations of the instrument. A strong understanding of the instrument makes choosing the appropriate scan parameters clearer thus getting more out of the instrument. Following is a description of some of the key capabilities and features of the **Alpha-Step Development Series** profilers:

- The **Alpha-Step Development Series** profiler has a vertical scan range of up to 1.2 mm, without requiring any hardware options.
- The **Alpha-Step Development Series** profiler has a 16 bit vertical resolution on all instruments rivaling the highest resolution available on a desktop profiler.
- The **Alpha-Step Development Series** profiler can scan in both the forward and reverse directions.
- The **Alpha-Step Development Series** profiler has basic programmability to make multiple measurements and automatically save the data. (Available in the D-600 model only.)
- The **Alpha-Step Development Series** profiler can make 3D data sets and display the image in Apex software. (Available in the D-600 model only.)
- The **Alpha-Step Development Series** profiler records up to 400,000 data points for a single profile scan.

NOTE

The horizontal resolution is not only a function of the number of data points in a profile; it is also dependent on the stylus tip radius.

- The **Alpha-Step Development Series** profiler can scan at speeds ranging from 0.01 mm per second to 0.4 mm per second.
- Integrated vacuum stage with software control (for D-600).
- You can use movable cursors to make horizontal and vertical measurements that is displayed as either surface or step height data. The screen constantly displays these measurements.
- Real-Time updates to any selected calculation parameters in the **Data Analysis** tab. The **Analysis** tab also supports Windows Copy, Paste, and Cut functions to easily select results and Paste them into a spreadsheet.
- You can expand each cursor into a band to define a range (Average Mode). This enables averaging of step height measurements relative to two ranges rather than two points.

- The cursors can be used to specify new zero points for re-leveling. You can also level using the Average Mode by setting the two cursor ranges.
- The **Alpha-Step Development Series** profiler has Soft Zoom capability.
- Surface parameter values can be displayed in preset metric or English units. Units for horizontal measurements are set independently of vertical units.

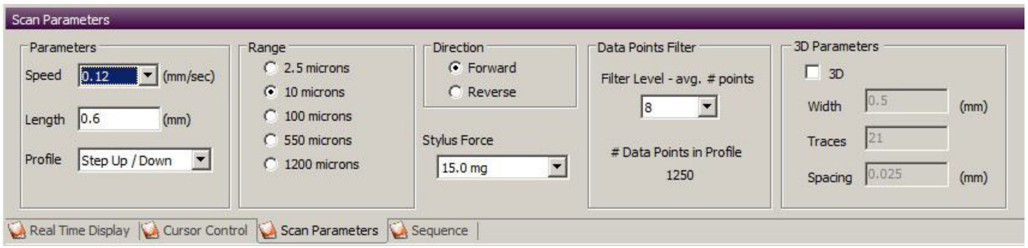
4.6.1 Scan Stage

The **Alpha-Step Development Series** profiler has an encoded scan stage with high-resolution stepper motors to ensure accurate speed control and distance measurements. The scan stage rests on a high quality optical flat to ensure a smooth linear movement of the scan stage with minimal out of plane motion.

The scan stage can measure in both the forward and reverse directions. The user can measure a sample in both directions along the same scan line without having to move the sample on the stage. 3D data acquisition is aided in some ways in Reverse mode.

4.7 Scan Parameter Tab

Figure 4-13 Scan Parameters Tab



The **Scan Parameter** tab is where the user selects all the scan parameters. After starting the **Alpha-Step Development Series** profiler Application software, the **Scan Parameters** tab is by default the visible tab along the bottom edge of the **Application** Window. At anytime the user can select the **Scan Parameter** tab with the cursor to bring it to the top position.

The **Scan Parameter** tab can be set to the **Alpha-Step Development Series** profiler Application environment. When it Floats it has the same characteristic as a Window. The user can dock the **Scan Parameter** Window at any time by double-clicking the top title bar of the Window. This restores the tab to its default **Dock** location.

4.7.1 Setting Scan Parameters

2-D Scan Parameters such as length, speed, stylus force, vertical range, scan direction, and data points must be chosen before a scan is taken. When 3D is checked, the scan can be a 3D scan and the values for parameters such as width, traces and spacing need to be entered.The **Scan Parameter** tab is where the user selects these parameters. In this section we describe how the user can change the parameters in the **Alpha-Step Development Series** profiler Application.

To edit the fields in the Scan Parameters window:

1. Position the cursor over the field you wish to change.
2. Click to highlight the field or click and drag the pointer over the field of interest to highlight the value. Release the mouse button.
3. Type the new value in the field.

Where an arrow indicates a drop-down list:

1. Position the cursor over the arrow and click to open the drop-down list.
2. Select the value you wish to enter in the field.

4.7.2 Definition of Scan Parameters

In this section a description of the scan parameters is given. Some parameters are described further elsewhere; a reference to any further information is given in the relevant parameter description. Following is a description of each of the scan parameters.

4.7.2.1 Parameters

Speed - This sets the scan speed of the stage in mm/sec. The maximum scan rate is 0.4 mm/sec. The minimum scan speed is 0.01 mm/sec.

NOTE

High speeds lose fine detail. Lower scan speeds are required to resolve the full height of a narrow peak, the edge of a corner, or the presence of a small feature.

Length - This sets the total scan length of the profile in millimeters.

The Alpha-Step D-500 maximum scan length is 30 mm.

The Alpha-Step D-600 maximum scan length is 55 mm.

NOTE

The minimum scan speed is limited by a minimum of 3 seconds scan time or larger than 30 µm. If the scan parameters do not result in a 3 second scan time an error message is displayed. You are not be permitted to continue until one or both of the parameters are changed so the scan time exceeds 3 seconds.

Profile Type –This parameter sets the start position of the height sensor before a measurement. It allows the user to make use of the full sensor range in cases where the sample is well known and the stylus can be started on a low or high spot. It is useful to choose the smallest range that is capturing the full height of the desired feature measurement. Using this capability maximizes the measurement resolution by not requiring the user to choose a larger scan range and thus a lower corresponding resolution.

There are three profile type settings available: Step Up, Step Down, and Step Up/Down.

Step Up – This sets the start position for a scan on the height sensor to be at the low point of the range. This enables the user to make measurements over tall features such as a step up or upward sloping surface without being cut-off by the detector. If the feature is greater than 50% of the chosen Range, more of the detector is set to leave room to see taller features.

Step Down - This sets the start position for a scan on the position sensor to be at the high end of the range. This enables the user to make measurements into deep features such as a trench or downward sloping surface without being cut-off by the detector. If the feature is greater than 50% of the chosen Range, more of the detector is set to leave room to see deeper features.

Step Up/Down - This sets the start position for a scan in the center of the detector. This setting has equal range up and down. This setting is recommended for most measurements and especially unknown samples.

NOTE

Step Up/Down is the only one that can be used for samples that require low force settings.

Range – This adjustment allows the user to choose the best full range to balance the full height of the sample measurement with the best resolution for the measurement. The chosen range represents the full height in Z available for a measurement. If the feature is larger than 50% of the scan range, it is clipped using the default profile type (Up/Down) unless one of the other Profile Type settings is chosen or the next largest Range setting.

NOTE

The 2.5 μm range only allows the Step Up/Down setting. It is required to ensure the high resolution and repeatability of these smaller ranges.

The range settings are: 2.5 μm, 10 μm, 100 μm, 550 μm, and 1200 μm.

Direction – This setting sets the scan stage scan direction. The scan stage can scan in the Forward and Reverse directions.

NOTE

The starting point for the Forward and Reverse direction is not the same. The user needs to first set the scan direction then reposition the stylus in relation to the sample feature to be measured.

Forward – The default direction is the Forward scan direction. This is the –Y direction in reference to the Sample Stage controls.

Reverse – The Reverse direction starts at the opposite end of the scan stage full range. This is the +Y direction in reference to the Sample Stage controls. The stylus lifts and waits for the stage to register at the opposite end and return to execute the profile for the first scan. Subsequent profiles respond normally without delay.

Stylus Force - This parameter allows the user to change the stylus force applied on the sample. The force control is only functional in the 2.5, 10, and 100 μm ranges in the Step Up/Down profile type. The force control range is from 15mg to as little as 0.03mg.

Filter Level – This defines the number of data points that can be plotted in the profile. The number in the box is how many data points can be averaged and then the average plotted in those points place. This is a simple smoothing filter. The instrument always acquires data at 2000 points/sec. It is useful for most measurements to apply a filter setting to minimize noise from over-sampling.

Data Points - This displays the number of data points after filtering so that the user can decide if the number shown is sufficient for the measurement at hand before moving on.

NOTE

The number of data points needs to be large enough so that the lateral resolution of the profile is limited by the tip radius and not the number of data points.

3D Parameters

Width - This defines the width of the 3D image size. If the scan length is 0.8 mm and the width in the 3D parameter is 0.5 mm, the image size is 0.8 mm by 0.5 mm.

Traces - this defines how many traces are used for the 3D image.

Spacing - this defines the spacing between two adjacent profiles for 3D scans.

4.7.2.2 Calculation Settings

The **Calculations Settings** are where the user chooses which physical parameters to calculate with the **Data Analysis** tab. These results are computed for either the specific Data Window or globally for all the open Data Windows.

The user can make calculations on Raw profile data, Low Pass filter for Waviness calculations and the High Pass filter for Roughness calculations. Following is a description of each of the features in the **Calculations Settings**.

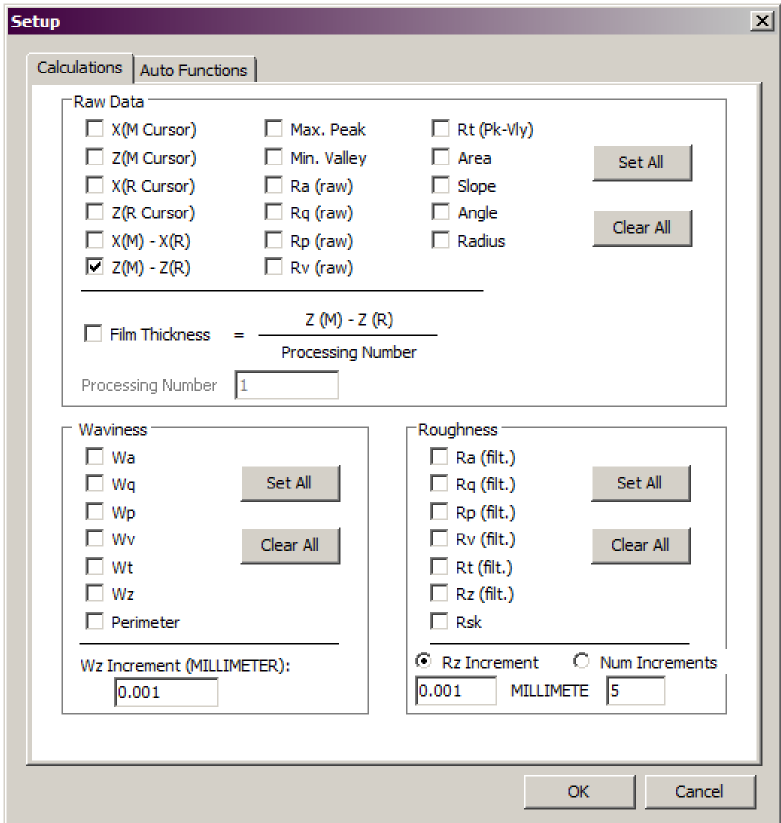
Opening the Calculations Settings window

The user can open the **Calculations Setting** window from the **Alpha-Step Development Series** profiler Application by selecting **Calculations** from the

Settings drop-down list. The **Calculations Settings** Window is displayed. The user can then select the parameters they wish calculated when an analysis is run.

Calculations Parameter Definitions

Figure 4-14 Setup Window Calculations Tab



Setup - Calculations tab lists the various standard data surface analysis calculations that are calculated and displayed in the Data Analysis Spreadsheet at the bottom of the screen.

Raw Data – These calculations are made on the profile data without a filter applied. A scan is assumed Raw, if it is loaded from a file or just scanned and displayed in a Data Window.

X (M Cursor) – This gives the X position of the Measurement cursor where it intersects the profile.

Z (M Cursor) - This gives the Z position of the Measurement cursor where it intersects the profile.

X (R Cursor) - This gives the X position of the Reference cursor where it intersects the profile.

Z (R Cursor) - This gives the Z position of the Reference cursor where it intersects the profile.

X (M) – X (R) – This gives the lateral distance between the Measurement cursor and the Reference cursor, from center-line to center-line.

Z (M) – Z (R) - This gives the Height distance between the Measurement cursor and the Reference cursor. This is the measurement used for step height.

Max. Peak —This is a measurement of the highest point of the profile from the mean line of the entire profile.

Min. Valley — This is a measurement of the lowest point of the profile from the mean line of the entire profile.

Average Roughness Ra (raw) — This is the arithmetic average of the absolute values of the profile height deviations recorded within the evaluation length (L) and measured from the mean line. $Ra = (|Z_1| + |Z_2| + |Z_3| \ldots.|Z_N|)/N$.

Root Mean Square Roughness (RMS) Rq (raw) — This is the root mean square average of the profile height deviations taken with the evaluation length (L) and measured from the mean line. $Rq = \{[(Z_1\text{-}Z_{avg})^2\text{+}(Z_2\text{-}Z_{avg})^2\text{+}\ldots\text{+}(Z_N\text{-}Z_{avg})^2/N]\}^{1/2}$.

Maximum Profile Peak Height Rp (raw) — This is the distance between the highest point of the profile and the mean line within the evaluation length (L).

Maximum Profile Valley Depth Rv (raw) — This is the distance between the lowest point of the profile and the mean line within the evaluation length (L).

Roughness (Peak – Valley) Rt (raw) – The P-to-V is a measurement of the lowest point to the highest point of the profile from the center-line of the R cursor to the center-line of the M cursor.

Area — The area is measured by projecting a line from the center-line of the Reference cursor to the center-line of the Measurement cursor and calculating the area subtended by the profile.

Slope - The slope is measured by calculating the slope of the line projected from the center dashed line of the reference cursor thru the center of the dashed line of the measurement cursor.

Angle – This calculates the angle in degrees of the slope determined by using the change in height between the Measurement and Reference cursors divided by the lateral distance between the Measurement and Reference cursors to the Baseline.

Radius – This calculates the radius of curvature determined by the distance between the Measurement and Reference cursors.

Film Thickness – The film thickness is calculated by dividing the step height by the processing number.

Waviness – These calculations are available when using the Low Pass filter in the **Cursor Control** tab. The calculations in the followings uses the same basic algorithm as described in the Raw Data section above. The calculations are made after the data has been filtered and displayed (refer to "Software Band Pass Filter" on page 115").

Average Maximum Deviation Wz – The average of the successive values of Wti (maximum peak-to-valley) calculated over the evaluation length (L). This parameter is the same as Wz (DIN) when there are five sampling lengths within the evaluation length (L).

Wz Increment (MICRON) – This is the evaluation length (L) used in calculating the Wz value above. The segment length must be evenly divisible into the profile length to function properly.

Perimeter - Perimeter is measured by calculating the lineal distance of all of the data points between the center dashed lines of the measurement and reference cursors.

Roughness – These calculations are only available when using the High Pass filter in the **Cursor Control** tab. The calculations in the followings use the same basic algorithm as described in the Raw Data section above. The calculations are made after the data has been filtered and displayed. Refer to Chapter 6, "Working with 2D Profiles," on page 83 for more information.

Average Maximum Deviation Rz (filtered) - The average of the successive values of Rti (maximum peak-to-valley) calculated over the evaluation length (L). This parameter is the same as Rz (DIN) when there are five sampling lengths within the evaluation length (L).

Rsk - The measure of the asymmetry of the profile about the mean line.

Rz Increment – This is the evaluation length (L) used in calculating the Rz value mentioned above. The segment length must be evenly divisible into the profile length to function properly.

Num Increments - This uses the data points to define the evaluation length used in calculating the RZ value mentioned above.

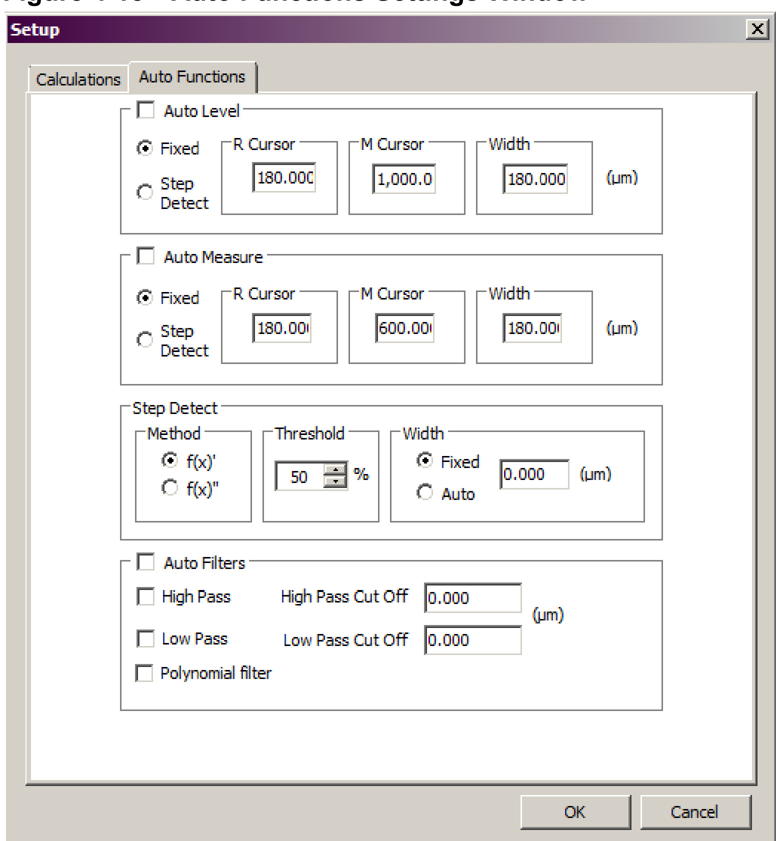
4.7.3 Auto Functions

The **Auto Function** tab is where the user can turn on and off the Auto Level and Auto Measure functions as well as choose the method of calculating the step. These tools are intended for step measurements on well-defined step features. It allows the user to apply a consistent method of leveling multiple data sets and then calculating a step height (or depth). These tools are not intended for measurements with many features included or with poorly defined step edges.

The controls allow the user to choose parameters then that can be automatically applied to any scans when the data is plotted or opened in a Data Window. The Auto Functions set parameters for leveling and/or measuring a profile by a predetermined method. The user can choose between set cursor locations or by a **Step Detect** algorithm.

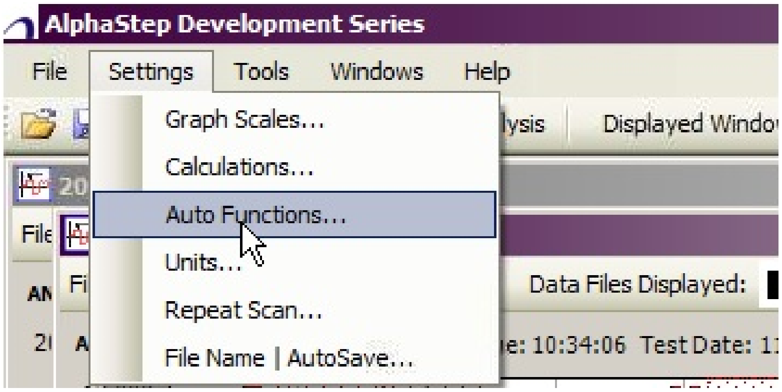
The Auto Functions Settings Window is displayed.

Figure 4-15 Auto Functions Settings Window



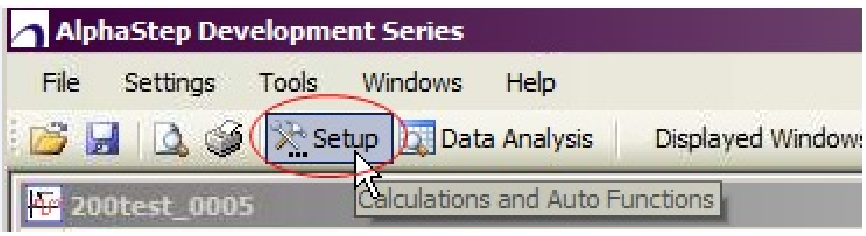
There are many ways to display the **Auto Functions Settings** window:

Figure 4-16 Accessing Auto Functions from Settings Menu



- In the Settings menu, click **Auto Functions** as shown in Figure 4-16**.** The **Auto Functions** window is displayed.

Figure 4-17 Accessing Auto Functions from Setup



- In the Application toolbar, click **Setup** as shown in Figure 4-17**.** The **Auto Functions** window is displayed.

4.7.3.1 Auto Functions Parameter Definitions

Auto Level – This feature allows the user to level the profile data in one of two methods, using fixed cursor locations or using the **Step Detect** algorithm.

Auto Measure – This feature allows the user to measure a step height in one of two methods, using fixed cursor locations or using the **Step Detect** algorithm.

Step Detect – By choosing this radial button the software calculates the Measurement and Reference cursor locations using the algorithm for **Auto Step Detect**. The **Step Detect** algorithm detects the first edge of the first step in a profile based on the Threshold value (refer to the following **Threshold** description). The Reference cursor is positioned to the left of this edge. The **Measurement** cursor is positioned to the right of the first edge and to the left of the second edge detected by the software using the same Threshold value. The software assumes the step is between the first and second detected edges that are greater than the Threshold value. The user can choose either Fixed Width or Auto (refer to the following **Auto Measure** function) to determine the Reference and Measurement cursor widths.

Auto Level

Fixed – This function allows the user to level the data by choosing specific cursor locations for the **Measurement** and **Reference** cursors. The user also can choose the width of both the cursors. Press the radio button to activate this function

R Cursor – This value is the X position of the Reference cursor that is used when the Fixed Level function is active. The user must enter a value smaller than the profile length and less than the value used for the **Measurement** cursor.

M Cursor – This value is the X position of the Measurement cursor that is used when the Fixed Level function is active. The user must enter a value smaller than the profile length and larger than the value used for the Reference cursor.

Width – This value is the width of both the **Reference** and **Measurement** cursors in the units of the X-Axis displayed in the **Data Display window**. The same width is used for both cursors

Step Detect – This radial button activates the level function using the algorithm for Auto Step Detect. The **Reference** and **Measurement** cursors are positioned to the left of the detected step. The position of the two cursors is determined by the distance of the leading edge of the detected step and the beginning of the profile. The user can choose either Fixed Width or Auto (refer to the following **Auto Measure** function) to determine the **Reference** and **Measurement** cursor locations.

Auto Measure

Fixed - This function allows the user to Measure a step height by choosing specific cursor locations for the Measurement and Reference cursors. The user also can choose the width of both the cursors. Press the radio button to activate this function

R Cursor – This value is the X position of the Reference cursor that is used when the Auto Measure function is active. The user must enter a value smaller than the profile length and less than the value used for the Measurement cursor.

M Cursor – This value is the X position of the Measurement cursor that is used when the Auto Measure function is active. The user must enter a value smaller than the profile length and larger than the value used for the Reference cursor.

Width – This value is the width of both the Reference and Measurement cursors in the units of the X-Axis displayed in the Data Display window. The same width is used for both cursors.

Step Detect

Method – The user can choose one of two algorithms to determine the step edges, 1st derivative (f(x)’) or 2nd derivative (f(x)”). The software uses the chosen method to find the first edge of a step that is greater than the Threshold value and the second edge of a step that is greater than the Threshold value.

Threshold – This value is given as a percentage value of the largest peak in the profile calculated using the 1st and 2nd derivative. The largest peak is given a value of 100%. All the other calculated peaks are scaled in proportion to the largest peak. The percentage value in the Threshold field causes the software to ignore any peaks that are smaller than the chosen percentage of the maximum derivative peak.

Width – This feature allows the user to choose a fixed cursor width or choose Auto width, each is described as follows:

Fixed – This field allows the user to enter a value in units of the X-Axis for the cursor widths. This value is used for both the **Reference** cursor and the **Measurement** cursor.

Auto – This field allows the user to choose the cursor width as a percentage value. The width of the **Measurement** Cursor is set as the percentage value of the detected step's width. The width of the **Reference** cursor is set as distance from the beginning of the profile to the first edge of the step multiplied by the percentage set in the **Auto text** field.

Auto Filters: This field allows the user to choose the cutoff filter to automatically separate the waviness and roughness component. For the detailed description, refer to Chapter 6, "Working with 2D Profiles," on page 83.

High Pass: This specifies the cutoff value for short wavelength filter cut off. The component with wavelength longer than the specified value is removed from the process profile.

Low pass: This specifies the cutoff value for long wavelength filter cut off. The component with wavelength shorter than the specified value is removed from the process profile.

Polynomial filter: When this filter is enabled, it finds step, removes the step from the data, ensures a low frequency fit to the data, removes the low frequency noise, and then re-creates the step. This filter improves the step height repeatability.

4.8 Using Scan Recipes

Scan Recipes are intended to simplify the measurement process for applications that use scan settings repeatedly or when many users are operating the instrument and want to retain important settings. In this section we can discuss how to load a Scan Recipe, scan from it and save a Scan Recipe.

NOTE

It is assumed that the operator has already made the changes to the Scan ***Parameters*** *tab before following the instructions in the following.*

4.8.1 Saving a Scan Recipe

1. From the profiler **Application** window, click the **File** drop-down list located at the top left corner of the screen.
2. Scroll the cursor to **Save Scan Recipe** and click once. A dialog box is displayed. The scan recipe is saved in **.rcp** file format.
3. Type in a File name and press **ENTER** or click **OK**.

4.8.2 Loading a Scan Recipe

1. From the **Application** window, click the **File** drop-down list located at the top left corner of the screen.
2. Scroll the cursor to Load Scan Recipe and click once. A dialog box is displayed. Two types of scan recipes can be loaded: rcp format saved with D-500/D-600 or txt format imported from an older version of D-series profilers.
3. Choose a File name and press **ENTER** or select **Open**. This loads the saved Setup parameters and Calculation parameters.

4.8.3 Changing a Scan Recipe

Often a new **Scan Recipe** is a slight variation of one you have already written. Rather than always using the default Setup parameters as a template, any **Scan Recipe** can serve the same purpose.

1. Follow the Loading a Scan Recipe directions above.
2. From the **Main** software screen, choose **File** and click once.
3. The **Scan Parameters** window is displayed with the Loaded Scan Recipe choices. Make any changes to the parameters.
4. Follow the steps in Chapter 4, "Saving a Scan Recipe".

5

Basic Operation

Contents

5.1 Introduction

This chapter describes the basic operation of the **Alpha-Step Development Series** profiler instrument and software. Included in this section are powering up the instrument, loading and unloading a sample, viewing and positioning with the video system and measuring a profile.

5.2 Powering up the Instrument

To start up the **Alpha-Step Development Series** profiler System, do the following:

1. Verify that the system power cord is plugged in.
2. Verify the computer and monitor are powered on. If not, press the Power button. Wait until the Windows Operating System is fully loaded, showing the desktop, before proceeding to the next step.
3. Turn on the power to the profiler on the back panel. Wait at least 10 seconds before running the profiler software to allow the Stage and computer to establish the USB connection.
4. Double-click the icon located on the Windows desktop.

The system raises the measurement head and then moves the sample stage to its home position.

5. The system is now ready to use.

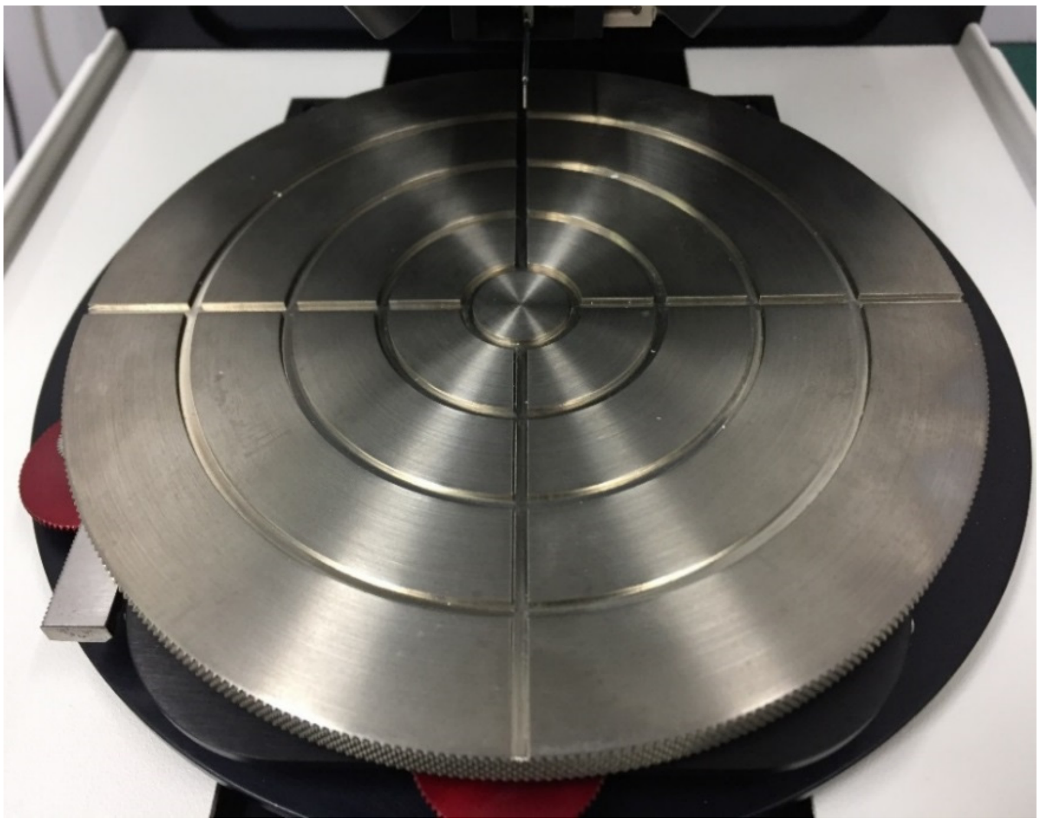
5.3 Loading the Sample

Loading a sample is a straightforward process. There is a process for the manual Alpha-Step D-500 instruments and a motorized process for the Alpha-Step D-600 instruments.

Loading the sample using the manual stage (Alpha-Step D-500):

1. Open the sample stage cover and place the sample on the stage table or precision locator. See Figure 5-1.

Figure 5-1 D-500 Stage Table



NOTE

If you are using the precision locator, it is normally used in the 0 position.

2. Using the finger dials, manually move the stage so the sample is moved under the stylus.
3. When you have roughly placed the sample under the stylus, use the Z Stage controls to lower the stylus until you can see the stylus and sample in the **Video** window.

NOTE

Do not bring the stylus down too quickly or you might crash the stylus into your sample surface and damage one or both of them.

4. Use the finger stage controls one at a time to fine position the sample under the stylus ready for a measurement.

Loading the Sample using the Motorized Stage (Alpha-Step D-600 only)

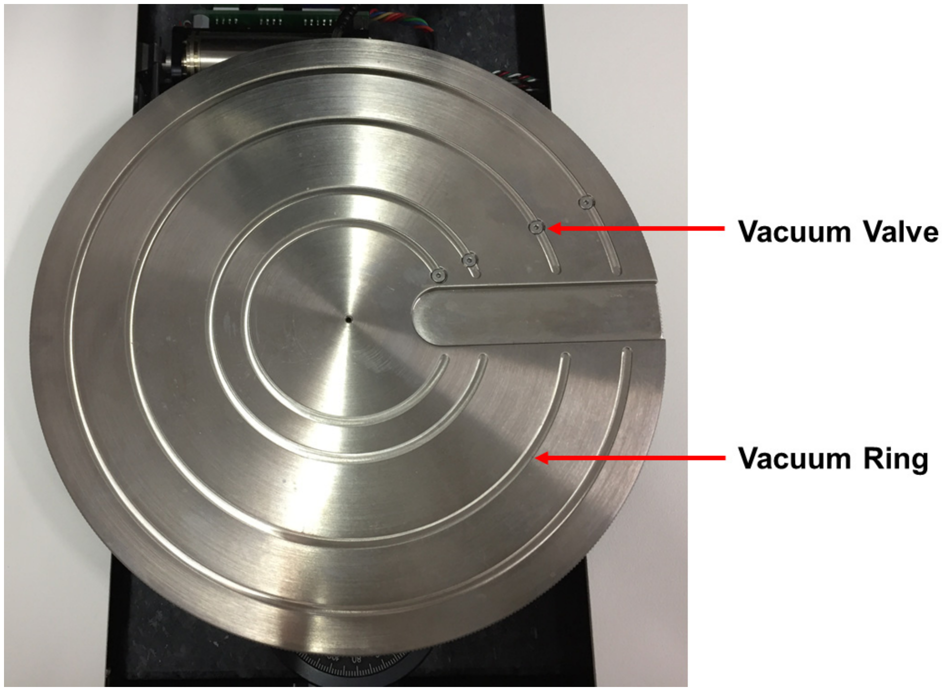
NOTE

Look to see that the stylus is not engaged or too close to the sample surface before proceeding further.

1. If the stage is not already at the sample load position (closest to the operator and out from under the stylus), on the **Control Panel** tab, click **Load Positions**, and use one of the preset stage positions or manually use the X-Y stage controls to move the sample stage out from under the stylus so you can safely load a sample, (see Figure 5-4 and refer to Load Positions on page 64).
2. After the stage moves to its forward **Load** position, a message is displayed on screen telling the user the stage is at the home position. Press **ENTER** or click **OK** to continue.

3. Open the sample stage cover and place the sample on the stage table or precision locator. See Figure 5-2.

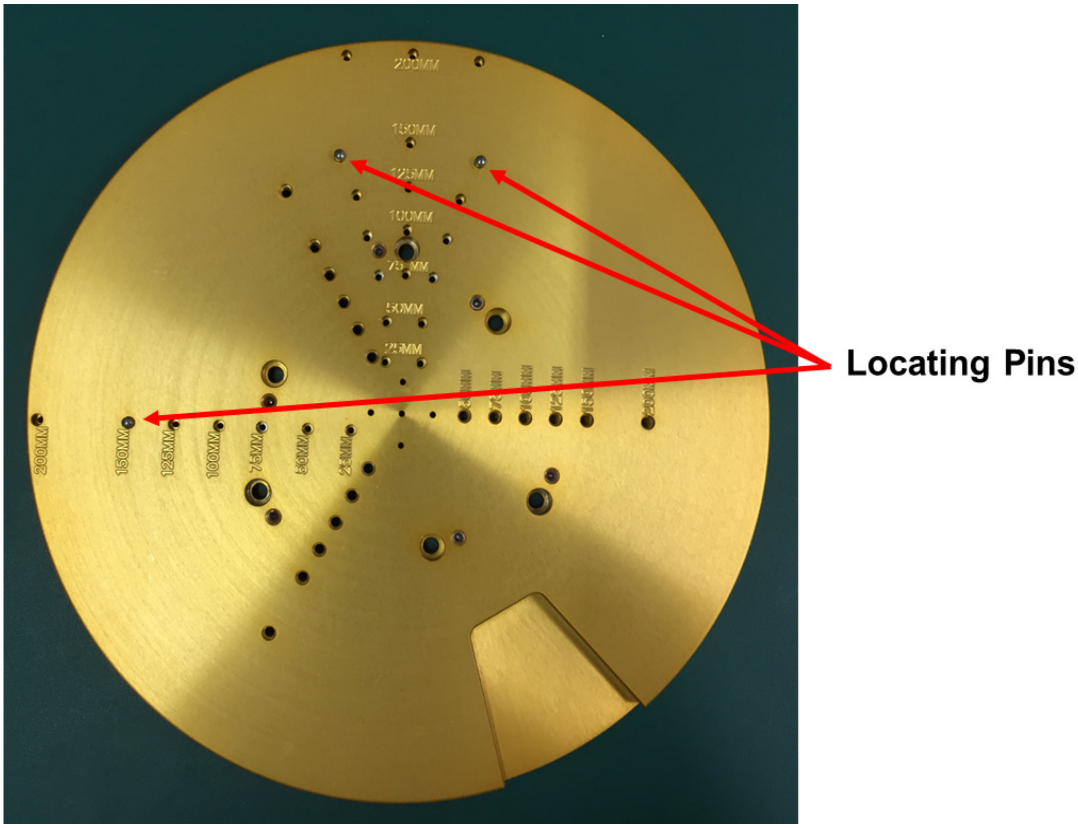
Figure 5-2 D-600 Stage Table



NOTE

If you are using the precision locator as shown in Figure 5-3, it is normally used in the 0 position. There are locating pins for precision locating, which support samples in the size of 2-8 in..

Figure 5-3 D-600 Precision Locator (Universal Chuck)



4. Engage the vacuum switch, click **Vacuum** located on the main software screen in the Z Stage controls panel, as shown in Figure 5-4. Users can find the vacuum unnecessary for their sample and can skip this step.

NOTE

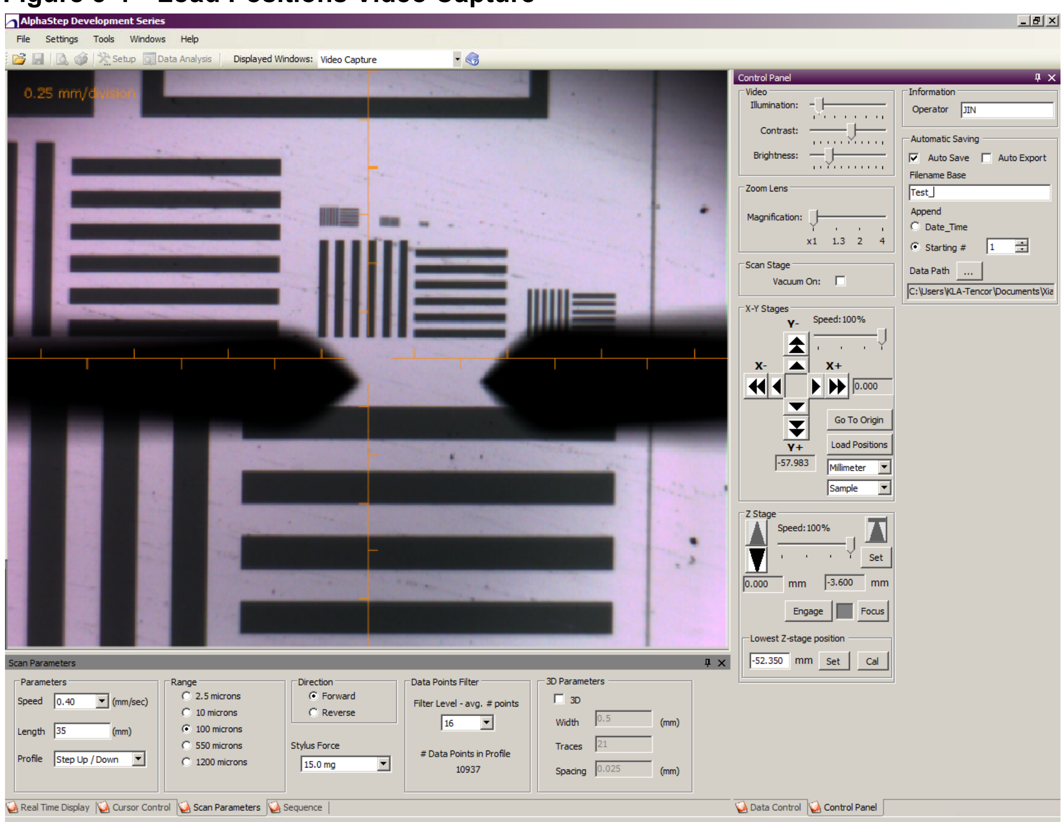
D-600 stage table has vacuum rings as shown in Figure 5-2, turning off a vacuum valve which prevents the vacuum flow outside the related ring. You can choose different vacuum rings for different sample sizes.

5. Move the stage in the Y+ direction using the X-Y Stage controls until the sample is positioned under the measurement head. The user can see roughly how close the sample is with the naked eye.
6. Use the X-Y controls to position the sample for a measurement (see Figure 5-4 for positioning in X-Y for more detailed description of using the X-Y controls).
7. Close the sample stage door cover.

NOTE

*Ensure that the measurement head is above the sample and clearly above the surface in the **Video** window or by using the naked eye to see that the tip is off the sample surface before closing the stage door cover.*

Figure 5-4 Load Positions Video Capture



5.4 Control Panel Tab

The **Control Panel** tab has all of the video, motor stage controls, together with data automatic saving function. This tab is where the user turns on or off the vacuum, adjusts video for brightness and contrast, adjusts magnification of the camera, move the stylus up and down when adjusting for setting up a measurement location and moving the sample stage.

The **Control Panel** tab can be set as a Window or Hidden. The Hide mode causes the tab to collapse along the right side of the **Application** window and not be visible. To see the tab again, the user moves the cursor over to the right edge of the window and the tab can be displayed again until the cursor is moved off the tab.

5.4.1 Video Controls and Zoom

The Video controls are divided into two groups:

Video – These controls adjust the view in the **Video** window. The video camera has a built in light level adjustment that is try to compensate for high light levels. This might affect the dynamic range of the contrast and brightness controls.

Illumination - The Illumination slider bar adjusts an LED light located on the Pivot assembly. Sliding the bar to the right makes the light brighter.

NOTE

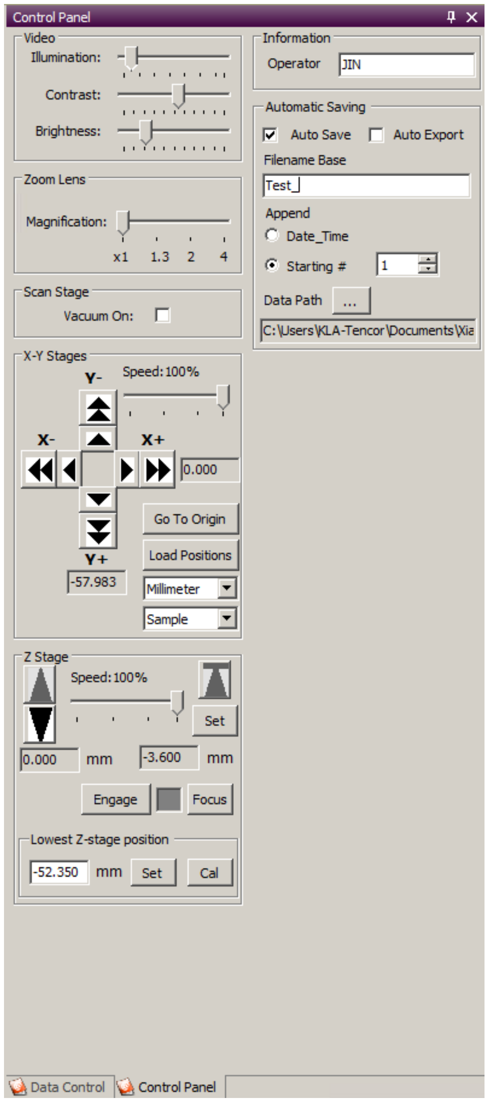
Leaving the light on high is a heat source and can cause the sample to heat up over extended time.

Contrast - The Contrast slider bar adjusts the video camera and video card contrast. Sliding the bar to the right increases the contrast level.

Brightness - The Brightness slider bar adjusts the video camera and video card brightness level. Sliding the bar to the right increases the brightness level.

Zoom Lens – These controls adjust the digital zoom in the video camera. There are four digital zoom magnifications: 1x, 1.3x, 2x and 4x.

Figure 5-5 Control Panel Tab



5.4.1.1 Viewing the Stylus in the Video Window

The **Alpha-Step Development Series** profiler measurement head integrates a high-resolution adjustable video camera. The video camera focus is set so that the stylus tip is always in focus. The user must move the Z stage to bring the sample into the field of view and focus of the stylus. After the sample has been loaded and the stage moved beneath the measurement head, the sample is visible in the **Video** window of the main software screen as shown in Figure 5-4 above. Using the **Video** window, the user can position the sample to the place of interest to start a scan. The sample motion consists of two parts:

- Z motion - motion of the measurement head up and down.
- X-Y motion - motion of the sample stage left and right, and back and forward.

5.4.1.2 Stage Positioning

The user can control the X-Y stage position and Z Stage up and down motion of the measurement head using the cursor, click the arrow control for the intended direction. (Theta) Motion (rotation of the stage or sample) is controlled manually by the user (Note: Alpha-Step D-600 only).

X-Y Stages - The X-Y Stage control consists of four double arrows, representing the right and left X motion of the stage and the forward and back Y-motion of the stage. The current stage coordinates are displayed next to the double arrows of X+ and Y+. Each arrow direction also has a single inner arrow that is 50% of the double arrow speed. A slider bar controls the speed of the X-Y motion. Moving the slider control to the right increases the speed of the stage motion. The arrow directions correspond with the video display frame of reference.

Unit display selection - This switches the display of the of X-Y stage position in unit of Millimeter or Inch.

Display reference - This switches the reference of the display. The Instrument uses the back of the X-Y stage as 0,0. The Sample uses the center of the X-Y stage as 0,0.

Speed Bar – This slider control adjusts the speed for all the X-Y arrow buttons. Moving the slider to the right increases the speed for each button.

Go to Origin - This button moves the X-Y stage to predefined origin position of the stage. The user can define any position of the X-Y stage as the origin position.

Load Positions – This button opens the Load Position Control. This Control allows the user to move the stage to pre-saved stage locations and to save stage locations for future use. For details about how to set the load positions, refer to Load Positions on page 32.

Z-Stage - The Z-stage controls consist of two arrows, and a speed bar control. The Z-stage moves the stylus up and down. It is necessary to move the stylus close to the sample surface can be able to see the stylus and the sample surface in the **Video Capture** window as shown in Figure 4-1.

Arrow Buttons – Pressing the up or down arrow moves the Z-stage up or down respectively.

Display Frame under Arrow Buttons - It displays the current Z-stage position.

Set Button - This button moves the Z-stage to a predefined set position of the stage. The user can define any position of the Z-stage as the set position. For safety concerns, the Z stage only moves to this position if the set position is higher than the current Z stage position.

Display Frame under Set Button - It displays the set Z stage position.

Lowest Z stage position - It is a soft limit and not allows the Z stage to move any lower (closer to the sample surface) than this predefined position. The user can manually input the predefined position and press the Set Button, or calibrate the predefined position with a sample by clicking the Cal button.

Speed Bar – This slider control adjusts the speed for the two Z arrow buttons. Moving the slider to the right increases the speed for each button.

Engage – This button is automatically lower the Z stage at a safe speed until it detects the sample surface and stops.

Focus - This button automatically lowers the Z stage at safe speed until it detects the sample surface and stops. The stylus is lifted and keeps a distance from the sample surface. After the process is completed, the user can move the sample under the stylus and keep the sample in focus.

5.4.1.3 Using the Stage Controls

To control the stage motion:

Click the double arrow direction in which you wish to move. Hold down the mouse button to continuously move in the chosen direction.

Click the single inner arrow to move at half the speed of the double arrow pointing in the same direction. Hold down the mouse button to continuously move in the chosen direction.

To adjust the Stage speed of motion, click the slider bar. Hold down the mouse button and move the mouse to the right to speed up the motion and to the left to slow down the motion.

Click the slider bar arrows and holding down the button also slides the speed control bar in the corresponding direction (see Figure 5-5).

5.4.2 Automatic Saving

The automatic saving contains Auto Save and Auto Export functions.

Auto Save - When Auto Save is enabled, the scan profile is automatically saved as XML format.

Auto Export - When Auto Export is enabled, the Data Analysis Results table is automatically exported as CSV format.

Filename Base - The filename base of auto-saved data and/or the auto-exported file.

Append - The appended filename after the filename base. Users could choose either the Data-Time or a starting number.

NOTE

When using Date_Time, it appends _YYYY-MMDD_HHMMSS.

When appending a number, it appends "_0000". For example, if the number is 10, it would append "_0010".

Data Path - Users should select a data path for the automatic saving files.

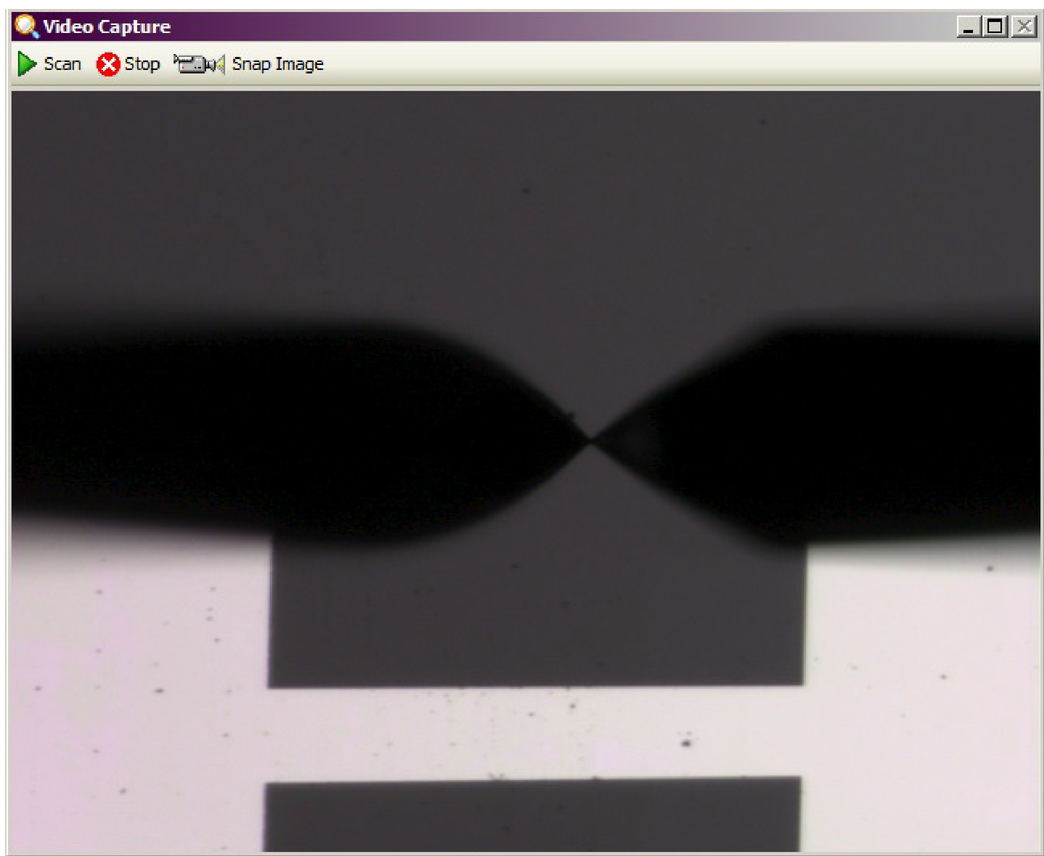
5.5 Engaging the Stylus

There are two methods to engage the stylus onto the sample surface: using the Engage button located on the Z stage control panel (see Figure 5-5), or by clicking **Scan** in the **Video Capture** window (see Figure 5-4).

5.5.1 Using the Engage Button

1. After the stylus is positioned over the sample, click **Engage** in the Z Stage control panel and click once. The profiler automatically brings the stylus down onto the sample surface and stops.
2. If the measurement requires precise positioning, first click Focus in the Z stage control panel, then move X-Y stage to the desired position, and then engage the stylus.

Figure 5-6 Stylus Near Sample Surface



NOTE

Always raise the stylus off the sample surface before moving the sample to a different location. Failing to lift the stylus off the surface before moving the X-Y stage can damage the stylus and the sample.

5.5.2 Using the Scan Button

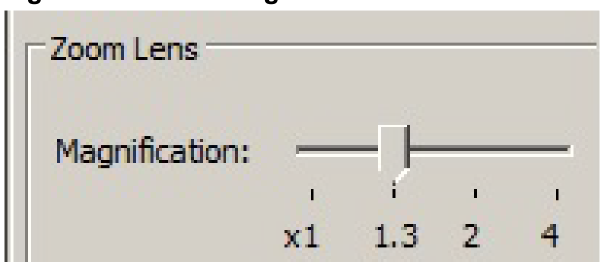
1. After the stylus is positioned over the sample, Click **Scan** located in the **Video Capture** window of the Main software screen. After the **Scan** is clicked, the instrument automatically engages the stylus on the sample surface and begins the scan. To cancel **Engage** or **Scan** the user can click **Cancel** located next to the **Scan** in the **Video Capture** window.

NOTE

Remember to raise the stylus off the sample surface and home the scan stage before repositioning the sample.

5.6 Magnifying the Sample Image

Figure 5-7 Lens Magnification Control



The user can magnify the sample video image to see more detail or make it easier to get a specific feature location. This zoom function is a digital zoom, and there are four zoom factors: 1x, 1.3x, 2x and 4x. After the zoom factor is selected, the software stores the factor for future usage.

5.7 Profiling a Sample

Getting a profile using the **Alpha-Step Development Series** profiler is a very simple and straightforward process. After the user understands what settings to choose for the scan Parameters, there are some steps to be followed for getting the scan data. They are as follows:

1. Load the sample.
2. Position the sample under the stylus and focus on the area of interest.
3. Press the **Scan** button. For 3D scans, the user is need to select a directory and input the file name after press the Scan button. After the scan finishes, the 3D results are automatically saved.
4. Display the Profile. For 3D scans, after the scan finishes, Apex is automatically open with the scan image.
5. Save the results for 2-D scans.

5.7.1 Loading a Sample

Follow the instructions for the appropriate profiler instrument, manual or motorized models in "Loading the Sample" on page 57.

1. Open the stage cover
2. Place the sample on the stage. Align the sample so that the profile is along the path of interest.

NOTE

The profile is scanned along the Y stage direction. The default direction is from the back to the front of the instrument, the –Y direction.

5.7.2 Position the Sample

Follow the instructions for the appropriate profiler instrument, manual or motorized models in "Control Panel Tab" on page 62.

1. Either manually or with the motor controls, move the sample stage so the sample is under the stylus.
2. When you have roughly placed the sample under the stylus, use the Z Stage controls to lower the stylus until you can see the stylus and sample in the **Video** window. Click **Focus** in the Z stage control panel, the sample to be in focused position and the stylus to be lifted from the sample surface.

NOTE

Do not bring the stylus down too quickly or you might crash the stylus into your sample surface and damage one or both of them.

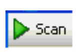
3. Use the fine position controls, either manual or motorized depending on the profiler model, to adjust the sample under the stylus until it is in position ready for a measurement.

5.7.3 Set Scan Parameters

Follow the instructions for choosing the appropriate Scan Parameters. Refer to "Scan Parameter Tab" on page 42 more detailed information.

1. Select the **Scan Parameter** tab on the bottom portion to be visible.
2. Set the scan parameters appropriate for the measurement

Click Scan



1. Click **Scan** located in the upper left corner of the **Video Capture** window. For 3D scans, the software asks the user to select the folder and input a file name for the 3D scan. The 3D scan result is automatically stored after the scan finishes.
2. The stylus automatically lowers towards the sample surface until it engages the sample surface.
3. If the user does not Abort the scan by clicking Cancel, the instrument automatically begins the scan. The Real Time Display shows the profile as it is scanned.
4. When the scan is completed, the stylus lifts off the sample surface, the stage returns to its starting position above the start-of-scan location, and the **Data Display** window is opened with the profile plotted in dimensioned coordinates (see Figure 5-10). For 3D scans, the scan result is automatically open in Apex.

Display the Data

For 2-D scans, the profile is automatically displayed in a new Data window after the scan is completed. For 3-D scans, the final results is automatically opened in Apex. The profile is ready for further analysis.

Save the 2D Profile

1. From the Data window Open the File drop-down list.
2. Select **Save Data File** or **Save As Data File**. A dialog box is displayed.
3. Type the name of the file you want to save in the dialog box and press **ENTER**.

NOTE

*The **Alpha-Step Development Series** profiler Application can be set to automatically save a profile after each scan. A description of the Auto File Name function is given in* *Chapter 4, "Description of Features," on page 23**.*

5.8 Profiling from a Scan Recipe

To profile a sample, the instrument moves the scan stage beneath the measurement head while the stylus rests on the sample. The up and down movement of the stylus is detected by a laser and provides the profile data.

The Setup File screen specifies how the stage moves and how the data is to be analyzed. The **Scan Parameters** tab displays the settings for the scan speed, scan length, scan range, stylus force, maximum number of data points, and the profile type (only available on 10 μm and larger scan ranges).

The “Scan Parameter Tab” on page 42 describes the technique for changing the scan parameters. Parameters should be changed, if needed, before initiating a scan. For this section, it is assumed that the scan parameters are already correctly set (refer to Chapter 4, “Setting Scan Parameters,” on page 42 for a description of the setup parameters).

5.8.1 Loading a Scan Script

The Scan Scripts are saved in a default directory in the **Alpha-Step Development Series** profiler Application folder. In the software directory there is a Setup folder. All the scan scripts and sequence scripts are saved in this folder unless the user manually chooses another location.

NOTE

It is not recommended to use a different folder location for saving the Scripts.

To view **Scan Script** parameters you first have to load a **Scan Script**:

1. In the **Application** window, select the **File** drop-down list.
2. Select the **Load Scan Script**.
3. A Windows File dialog box opens to the default directory.
4. Select the Scan Script you wish to view. The software allows to load scan recipes with rcp or txt formats.
5. The Scan Script parameters are automatically entered into the **Scan Parameter** tab fields.
6. Review the Scan Parameter values and make changes if necessary before starting a scan.

To start Scan

1. Click **Scan** located on the **Video Capture** window.
2. The stylus descends to engage the sample surface. The Real Time Scan **Display** (located on the Main software screen below the **Video image** window) shows a trace as it is generated.
3. When the scan is completed, the stylus lifts, the stage returns to its starting position above the start-of-scan location, and the Data Display window is displayed with the profile plotted in dimensioned coordinates (see Figure 5-11). 3D scan result is automatically opened in Apex.

NOTE

The trace runs off scale or is not horizontal, refer to ""Manual Stage Leveling" on page 77.

To Abort a Scan

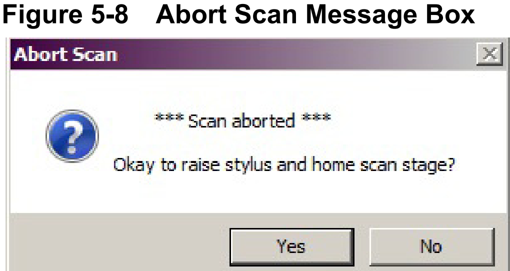
There are two ways to stop a scan after it is started; Click **Stop** on the top left corner of the **Video Capture** window or Press **ESC**.

NOTE

The scan can only be stopped after the stylus is engaged and the stylus has started moving.

After clicking **Stop** or pressing the **ESC**, a message is displayed: **Scan aborted. Okay to raise the stylus and home the scan stage?**

Figure 5-8 Abort Scan Message Box

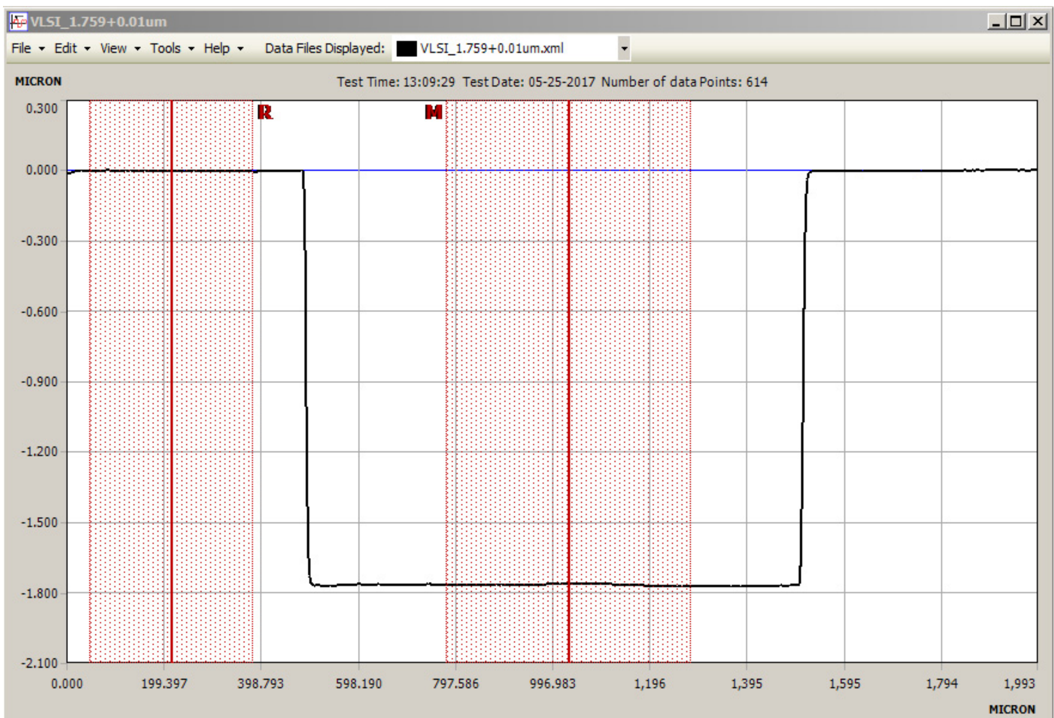


If you choose **No**, to lift the stylus off the sample surface:

- On the Control panel, in the Z stage pane, click the up arrow. Click once to disengage the tip off the sample surface then raise the Z stage up a short distance to allow safe positioning of the sample under the stylus tip.
- Ensure that in the video view and/or visually, the tip is clearly above the sample surface.
- **Focus** in the Z stage control panel is a good choice to lift the stylus off the sample surface and keep the sample in focus position.

5.9 Reading the Cursors, Saving and Printing Data

Figure 5-9 Sample Data Window



After the scan is taken, a new Data window displays the profile. The profile displayed in the graph display; the **Data Control** tab is automatically opened along the right side of the **Application** window. The **Data Control** tab displays the cursor information and leveling controls (for more detailed description of the **Data Control** tab, refer Chapter 6, "Data Analysis Tab," on page 110).

5.9.1 Reading the Cursors

The cursor positions are displayed in real-time in the **Data Control** tab. There are always a set of Primary cursors displayed in a Data Window, the Reference and Measurement cursors (R and M respectively).

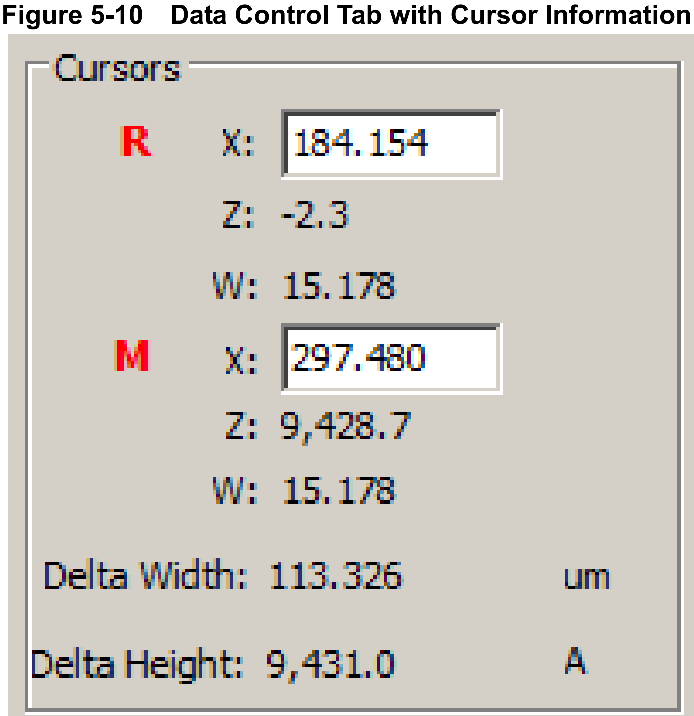
To Move the Cursors

- To move the R cursor, position the mouse on the R cursor, click and hold the button. Move the mouse right or left to reposition the cursor in a desired location.
- To move the M cursor, position the mouse on the M cursor, click and hold the button. Move the mouse right or left to reposition the cursor in a desired location.
- The Delta Width and Delta Height calculate the difference or X distance between the two cursors and the difference or Z height respectively where the cursors intersect the profile.

The Delta Width - The horizontal distance between the R and M cursors (see Figure 5-10) along the X-Axis.

The Delta Height – The vertical distance between the R and M cursors (see Figure 5-10) where they intersect the profile along the Z-Axis.

Figure 5-10 Data Control Tab with Cursor Information



Printing Data

1. From the **Data** window, click the **File** drop-down list.
2. Click **Print Graph**. A Standard Windows **Print** dialog box is displayed.
3. Select a printer and make any necessary changes to the printer settings before continuing.
4. Click **Print.**
5. The current view of the profile data is sent to the default printer.

NOTE

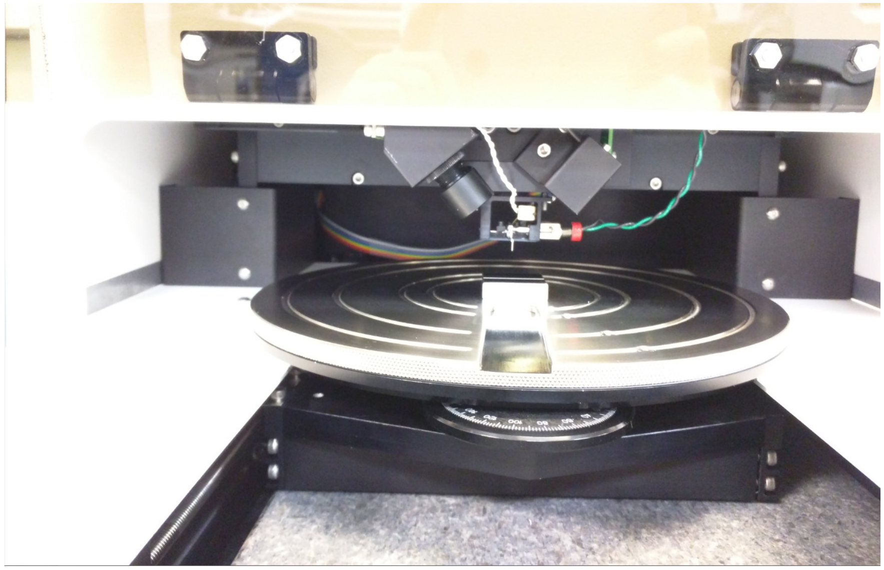
You can also review the profile before printing in the Print Preview page.

Saving Data

1. From the **Data** window, click the **File** drop-down list.
2. Click **Save Data File**. A dialog box is displayed.
3. Type the name of the file you want to save in the dialog box and press **ENTER**.

5.10 Manual Stage Leveling

Figure 5-11 Front View of Stage with Tilt Control Knob



When making profile measurements toward the front or back of the stage, you can notice a significant tilt so that the profile displayed in the **Real Time Scan Display** window is at a severe diagonal or even clipped by moving off scale. This can be adjusted with the tilt adjustment. The stage has an adjustment along the scan direction. This adjustment dial changes the tilt along the Y-Axis (toward or away from the front door panel of the stage). Following is a description for adjusting the stage in the case of the profile that tilts uphill.

NOTE

It is assumed that in the description that the sample being measured is placed in the center of the stage.

The stage tilt adjustment knob is in the front of the sample stage, see Figure 5-11.

Turning the knob clockwise moves the front of the stage down.

Turning the knob counterclockwise moves the front of the stage up. Adjusting stage tilt using the **Real Time Scan Display**:

1. Position the stage and measurement head to take a scan.
2. Scan a sample.
3. Watch the Profile trace in the **Real Time Scan Display** window.
4. Adjust the Stage tilt using the following:

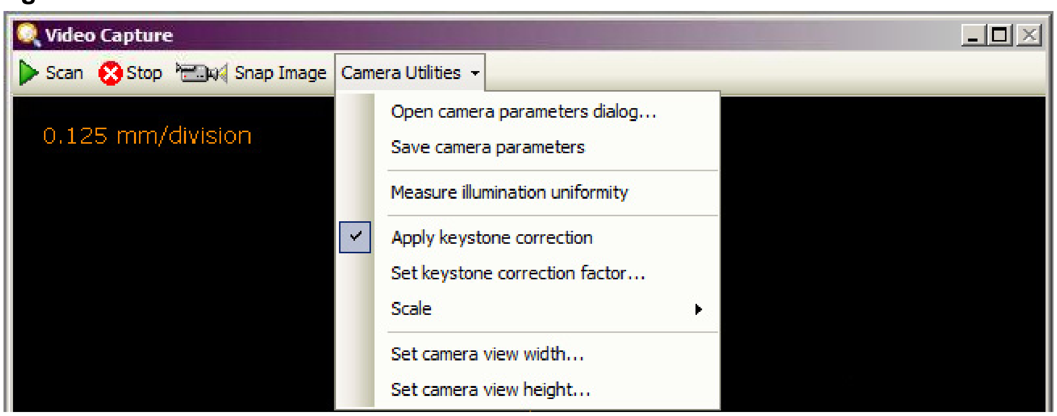
If the profile is tilting upwards from left to right, turn the adjustment knob in the counter clockwise direction to level the scan, clockwise if the profile is tilting downward.

5.11 Camera Settings

Camera Utilities is used to set up the camera parameters for the video view. It is normally hidden. Use the **CTRL + M** to bring up the Camera Utilities on the top of video view as shown in Figure 5-12.

There are many parameters for setting up the camera. Most of them are already pre-calibrated and does not need any change. Several common used functions are selected to show how they work.

Figure 5-12 Camera Utilities



5.11.1 Camera Parameters Dialog Box

This dialog box contains the parameters to display the video view. Most of the parameters are already optimized for the video view and we strongly suggest NOT adjusting them.

If some of the parameters need be adjusted for some reason, make a copy of the original values before the adjustment so that you can return to the original settings. After the parameters are adjusted, close the Camera Parameter dialog box and click **Save camera parameters** under Camera Utilities to save the change. Two of the camera parameters are useful for certain customers:

- Auto Gain: Auto gain is a function to automatically adjust the video gain when imaging samples with different reflectivity. To turn on auto gain:

1. Press **CTRL + M** to enable the Camera Utilities function it is not available on the top of video view.
2. Select the **Open camera parameters dialog** under **Camera Utilities**.
3. Select the **Image** tab.
4. Select **Auto** under **Master gain** from **Hardware Settings**.
5. Click **OK** to close the Camera Parameters dialog box.
6. Under **Camera Utilities**, click **Save Camera Parameters** to save the change.

- Color temperature: This is to adjust the display color of the sample. To change the display color:

  1. Press **CTRL+ M** to enable the Camera Utilities function it is not available on the top of video view.
  2. Select the **Open camera parameters dialog** under **Camera Utilities**.
  3. Select the **Image** tab.
  4. Change the gain factors for the three base colors: Red, Green and Blue. Each of them has its own gain factor. Adjust the gain factors to get the preferred display color.
  5. Click **OK** to close the **Camera Parameter** dialog box.
  6. Under **Camera Utilities**, click **Save Camera Parameters** to save the change.

5.11.2 Save Camera Parameters

After any parameter is adjusted in Camera Parameters dialog box, the user must click this function to save the changes.

5.11.3 Measure Illumination Uniformity

This measures brightness variation of the video view. When this function is selected, three parameters of the sample brightness are displayed on top of the video view:

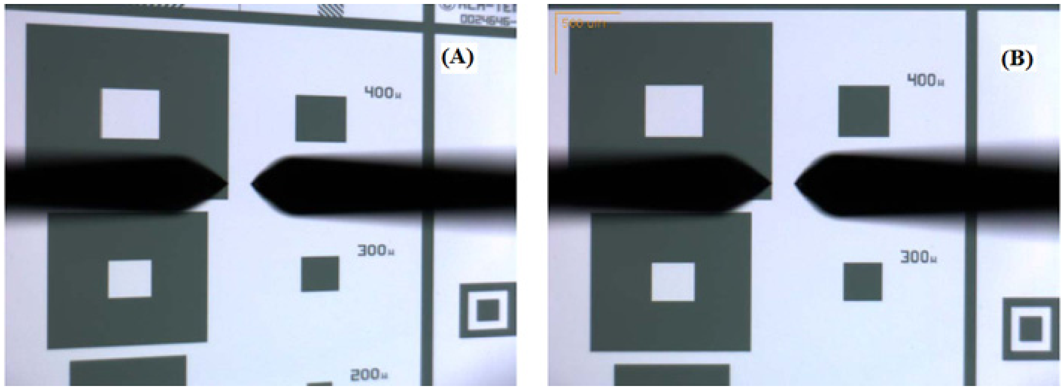
Max – the maximum brightness of all the pixels of the camera

Min - the minimal brightness of all the pixels of the camera

Delta – the difference between Max and Min

5.11.4 Keystone Correction

Figure 5-13 Video Before and After Keystone Correction



The video camera assembly images the sample and the stylus with a 45 degree angle. The raw sample image directly from the video camera is skewed as in Figure 5-13(A).

To have a uniform sample image with video camera, the software has the keystone correction function to correct the image skew of Figure 5-13(A). Figure 5-13(B) is the camera image after the keystone correction. To toggle on/off Keystone correction:

1. Press **CTRL+ M** to enable the Camera Utilities function if it is not available on the top of video view.
2. Enable the **Apply keystone correction** function under **Camera Utilities**. Now the camera view is corrected with keystone and the scale bar is available on the top left corner of the video.
3. Disable the **Apply keystone correction** function under **Camera Utilities** to disable keystone correction.
4. To hide the **Camera Utilities** functions, press **CTRL+M** again.

NOTE

During scanning, the Keystone correction is temporarily disabled.

5.11.5 Set Keystone Correction Factor

Do not change this value. This is the value used in keystone correction.

5.11.6 Select Scale Type

The user can select grid scale or X-Y scale for the video view.

5.11.7 Set Camera View Width/Height

Do not change these values. These are the size of the video view.

6

Working with 2D Profiles

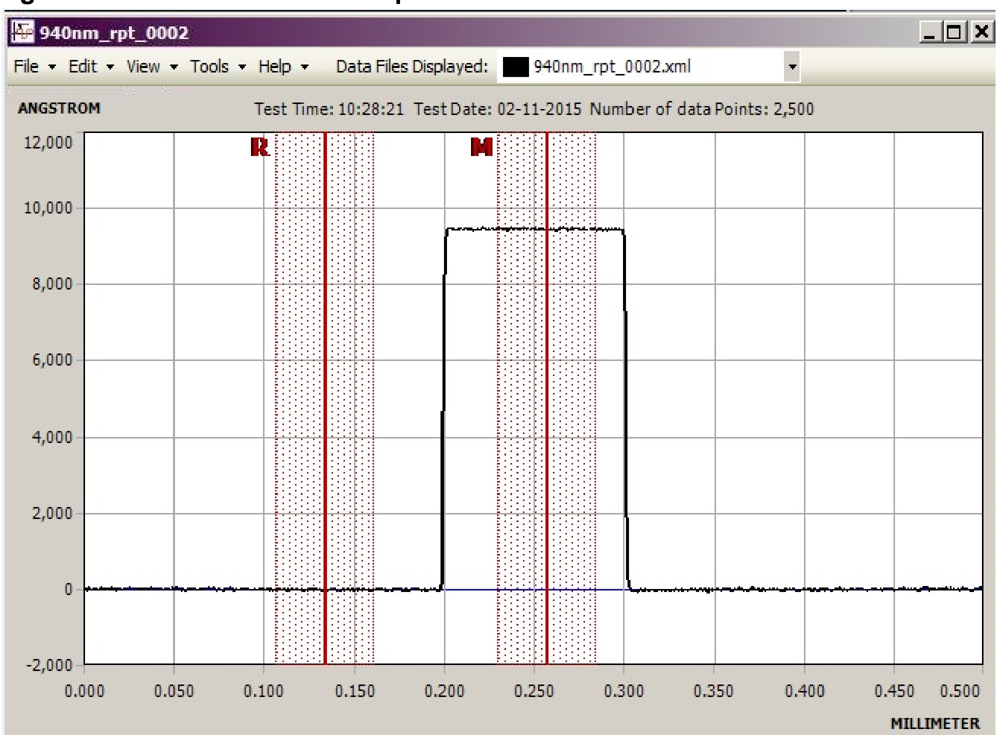
Contents

6.1 Introduction

After you have Setup the Scan parameters (Chapter 4, “Description of Features,” on page 23) and taken a scan (Chapter 5, “Basic Operation,” on page 55), the software displays the profile in a Data window. Chapter 5 discusses using the Data window and **Data Control** tab to analyze and manipulate the data. The data or profile in this chapter refers to 2-D profiles unless otherwise specified.

6.2 Data Analysis

Figure 6-1 Data Window Example



The **Alpha-Step Development Series** profiler software supports multiple profiles displayed in a single Data window (up to 10 profiles in a single window). The profiler Application also allows many Data windows to be displayed at the same time. The user has several ways of moving between the open Windows.

After a profile scan is completed and displayed in the Data window, or a profile is loaded into the Application the software automatically displays the Data window on top of the **Video** window; the software also moves the **Data Control** tab along the right side to the top and the **Cursor Control** tab along the bottom of the **Application** window. The description of the Data Window, **Data Control** tab, and **Cursor Control** tab are given as follows.

6.2.0.1 Data Windows

Any profile data, either directly after making a scan or after opening a previously saved data file, is displayed in a Data window. The profiler software can display 25 Data windows at the same time, or more with a simple registry change.

NOTE

There is a limit of 10 profiles displayed in the same Data window.

The Data window has the following features:

Drop-down lists – The drop-down lists are described in detail in a following section.

Alternate drop-down list – The alternate drop-down list is opened by using the right mouse button inside the graph region. The menu is shown in Figure 6-2. A detailed description of the features is given as follows.

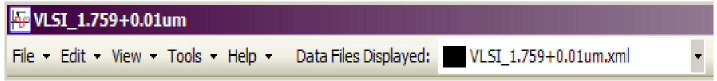
Cursors - The controls contain the X and Z position values of the Reference cursor (R), the Measurement cursor (M), and the mouse cursor. It also has the difference between the relative X and Z positions of the R and M cursors. The values are continuously updated to reflect the current position of all the cursors. The user can enter a specific value into the X or Z position text box to move the cursor to that position on the profile.

The Leveling Cursors - The R and M cursors are also used as the Leveling cursors. The leveling function is described later "Leveling the Profile" on page 97.

The Graph – This contains a plot of the profile height (the vertical axis) at each horizontal location within the scan (the horizontal axis). The graph can display the raw data or the filtered roughness or waviness data, or both. The graphs' axis are scaled as determined by the **Graph Setup** window (refer to "Scaling Data" on page 109). The default setting is AutoScale in the Z-Axis and the length of the profile as set in the **Setup** window for the X-Axis. Multiple files that are imported into the same window can be directly compared with the AutoScale function turned off. The measurement cursors also displayed in this window and are manipulated as described in "Measuring Profile Features" on page 102.

Data Window Drop-Down Lists

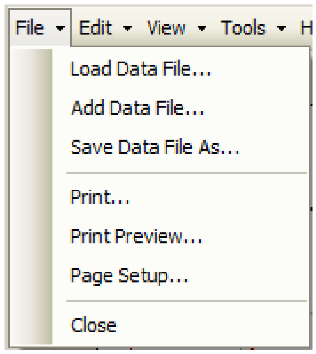
Figure 6-2 Data Window Tool Bar Drop-Down Lists



The **Data** Window drop-down lists are features that apply to any of the Data Windows. If a drop-down list lists an item that is unavailable this means the function is not available and requires changing a setting to activate it. A description of the drop-down lists is given as follows.

File Drop-Down List

Figure 6-3 File Drop-Down List



Load Data File - This opens the Data Folder. Saved profiles can be loaded into the profiler software for further analysis. Choose a filename to load the profile data. The profile is then viewed by opening the **Data Display** window.

Add Data File - This allows the user to load additional profiles into the same Data window. The data files must have the same settings or the software is not allowing the user to load the file.

Save Data File – This opens a standard **Windows Save** dialog box. The dialog box prompts you to name and save the profile in the active Data window. The profile is saved in the Data folder in the software folder as an XML file. An option to save as a DAT text file is also available.

Print – This opens the standard **Windows Printer** dialog box prompting the user to choose a printer and the printer set up.

Print Preview – This opens a standard Windows preview window that displays the current profile data as it would look for printout.

Page Set-up – This displays a standard Windows **Printer Set-up** window that allows the user to choose the printer settings before printout.

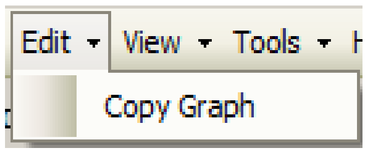
Close – This closes the Data window.

NOTE

When the Data window is closed it does not prompt the user to save the data first. Any unsaved data might be lost.

Edit Drop-Down List

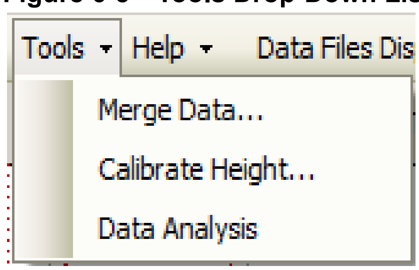
Figure 6-4 Edit Drop-Down List



Copy Graph –This functions just like the standard Windows Copy feature. It allows the user to copy a Data window to the Clipboard, it can then be Pasted into another program or presentation. Ensure that this function only copies the scan data, it does not copy the cursors.

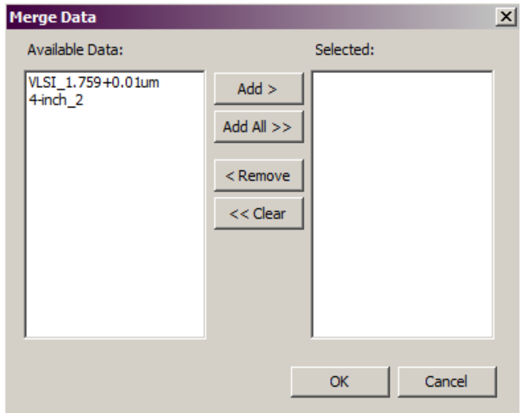
Tools Drop-Down List

Figure 6-5 Tools Drop-Down List



Merge Data – This opens the **Merge** Data Control. The user can merge up to 10 files into the active Data window. The user must first have separate Data windows open with the profiles that they wish to be **Merged** into the active Data window.

Figure 6-6 Merge Data Control Window



Available Data – this field lists the profiles available to Merge other than the active Data window.

Selected – this field lists the profiles that have been selected to Merge into the active Data window.

Add Button – Using this button adds a single selected profile from the Available Data field.

Add All Button – This button adds all the profiles listed in the Available Data field to the list in the Selected Data field.

Remove Button – Using this button removes a single selected profile from the Selected Data field.

Remove All Button – This button removes all the profiles listed in the Selected Data field.

Clear Button - This button removes all the profiles listed in the Available Data field.

Calibrate Height – Begins the instrument height calibration procedure.

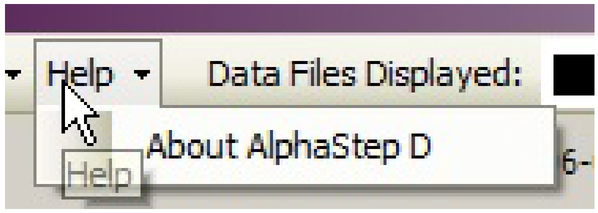
NOTE

It is expected that the user has already placed the calibration standard onto the stage and made a first measurement (more detailed description of the procedure is given in Chapter 10, “System Maintenance”)

Data Analysis – Calculates the parameters selected in the Calculations Control and then displays the results for the active Data window in the **Data** tab (a more detailed description of the data analysis and **Data** tab is given as follows)

Help Drop-Down List

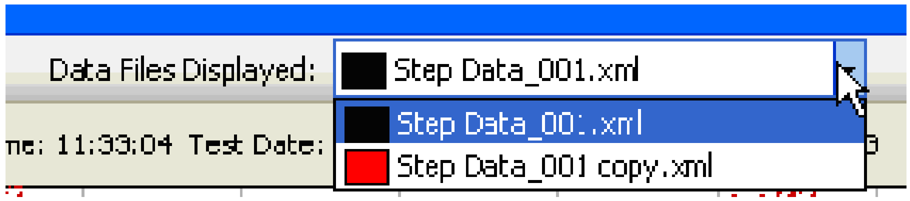
Figure 6-7 Help Drop-Down List



About Alpha-Step D - This opens a splash screen presenting information about the software version and copyright information.

Files Displayed in Drop-Down List

Figure 6-8 Files Displayed in Drop-Down List



The title bar of the Data window has a drop-down list that shows the active profile in the Data window. If there are multiple profiles loaded in the Data window, the drop-down list shows the other profiles in the order they were loaded into the Data window.

Figure 6-9 Data Window Alternative Drop-Down List

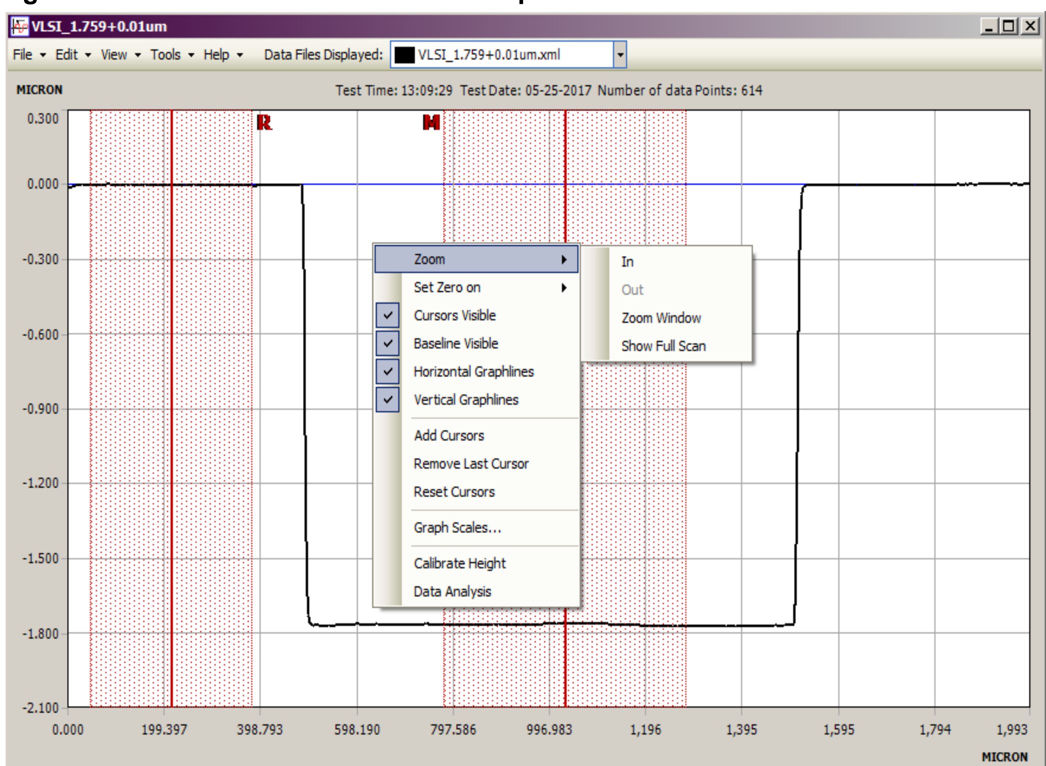


Figure 6-9 Shows commonly used tools that are also found in the Tool Bar drop-down lists.

Data Window Alternate drop-down list

There is a secondary way for the user to access some of the more common functions inside the Data window, an alternative menu. With the cursor inside the graph region press the Right Mouse button, a drop-down list is displayed. The descriptions for the items are given as follows.

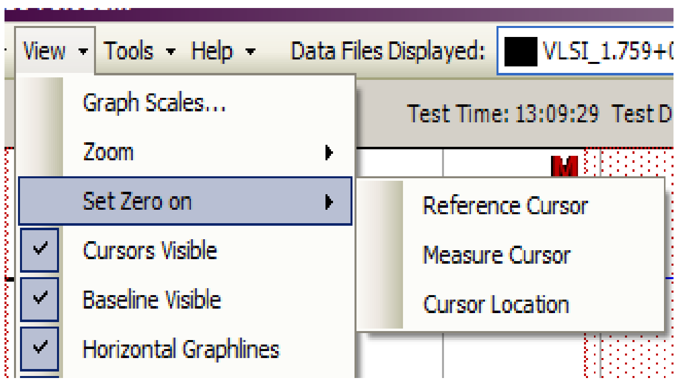
Zoom – Opens the lists of Data Analysis Zoom options.

- In – This option re-scales the profile data axis to half the previous view and centers the data in the Data window.
- Out – This option scales the data axis out by double the previous view. It is expands the view until the original data scale is reached
- Zoom window – This option places a zoom box in the Data window that the user can re-size and select a specific portion of the profile data to display in the Data window. A more detailed description is given in **"Data Analysis" on page 84**.
- Show Full Scan – This option returns the Data Display to the original profile full-scale view.

Set Zero On – This feature opens a list of options to set the zero reference point for calculating the measurement parameters.

- Reference Cursor – This sets the zero reference line for any parameter calculations to the location where the Reference cursor intersects the Profile data.
- Measure Cursor - This sets the zero reference line for any parameter calculations to the location where the Measure cursor intersects the Profile data.
- Cursor location - This sets the zero reference line for any parameter calculations to the location where the user places the cursor and then Presses the Left Mouse Button.

Figure 6-10 Data Window Alternative Drop-Down



Cursor Visible – This option toggles the cursors in the **Data Display** window on and off.

Baseline Visible – This option toggles the Baseline in the **Data Display** window on and off.

Horizontal Graph – This option toggles the horizontal scale lines in the **Data Display** window on and off.

Vertical Graph - This option toggles the vertical scale lines in the **Data Display** window on and off.

Add Cursor – Adds an additional cursor pair in the active **Data Display** window (up to 5 cursor pairs can be displayed in a single Data window). Refer to “Adding Additional Cursors” on page 105 for more a detailed description.

Remove Last Cursor – Removes the last cursor pair displayed in the **Data Display** window until there is only the original red cursor pair available in the window.

Reset Cursors – Removes all the cursors in the **Data Display** window except for the Main Red cursor pair.

Graph Scales – Displays the **Graph Scale** window. Refer to “Scaling Data” on page 109.

Calibrate Height - This option allows the user to set the instrument height calibration for the specific range in use at the time.

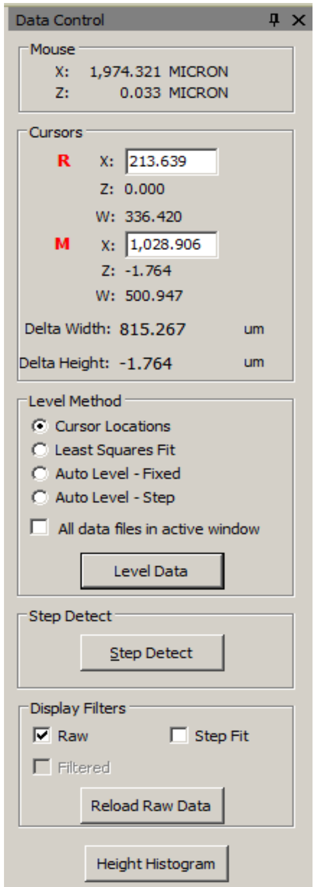
NOTE

Never use this function without the appropriate calibration standard. Follow the instructions in Chapter 10, “Calibrating the Measurement Head”carefully or you risk changing the calibration of the instrument and any measurements you make after that.

Data Analysis – Opens the **Data Analysis** tab and displays calculation results from the selected parameters in the **Calculations** tab. For more description of the Data Analysis features; refer to “Data Analysis” on page 84.

6.2.1 Data Control Tab

Figure 6-11 Data control Tab



Level Method - This box determines what method is used to level the scan data. There are 4 methods available:

- Least Square Fit – This leveling method is defined as: a line that minimizes the sum of the squares of the deviations of the measured values of Z from those predicted in the profile. In this case the best line fit is calculated on the profile data between the cursor locations. This method is recommended for non-step height measurements or surfaces where there is no obvious best place to level the data.
- Cursor Location – This method uses the location and width of the cursor to level the profile. Only the placement of the R and M cursors and the data shaded by the cursors in Average Mode are used to level the profile.
- Auto Level Fixed – This levels the profile using the settings in the **Setup** window **Auto Functions** tab, Auto Level section, and Fixed radio button (refer to Chapter 4, “Auto Functions,” on page 49).
- Auto Level Step – This levels the profile using the settings in the **Setup** window **Auto Functions** tab, Auto Level section, and Step Detect radio

button (refer to Chapter 4, “Scan Parameter Tab,” on page 42 for more details).

- All Data Files in **Active** window. If there are multiple data files added into the same window, and this option is checked, all the data files as in Figure 6-11, can be leveled by the selected leveling method.
- Level Data Button – This button when pressed uses the leveling routine with the radial button chosen: the Cursor Location, Least Square Fit, Auto Level Fixed, or Auto Level Step.

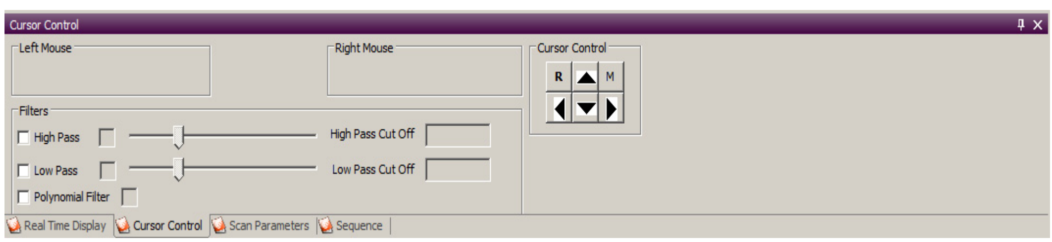
Step Detect Button – Pressing this button runs the Auto Step algorithm predefined by the user in the **Auto Parameters** window located in the Setup Parameters Control Panel (refer to Chapter 4, “Scan Parameter Tab,” on page 42 for more detailed description) on the profile in Focus.

Display Filters - When a filter is active, this box allows the user to choose whether to display the Filtered profile, the Raw Data profile or both. Each profile is displayed in a different color. Only the Raw Data radial button is available when no filtering is activated. There are four types of filtered functions possible, Low Pass, High Pass, Polynomial, and Step Fit. Refer to “Software Filter Settings” on page 115 for more information on the band pass filters and the Step Fit function.

Reload Raw Data button – This button re-displays the Raw Data Profile as it was before any filtering, leveling or other data manipulation was executed on the data set.

Height Histogram button – This button displays the **Height Histogram** window. The Height Histogram is described in “Height Histogram” on page -110.

Figure 6-12 Cursor Control Tab



Filters - This contains the High Pass and Low Pass cut off slide controls, text box for filter cut off value and on/off check box. Moreover, the on/off check box for the Polynomial Filter is also contained here. The Filter controls are described in more detail in “Software Filter Settings” on page 115”.

- High Pass – The High Pass filter control allows the user to turn on and off a filter for surface roughness analysis. The control allows the user to adjust a slider bar or directly type a filter cut off value into the text box corresponding to that filter.

- Low Pass – The Low Pass filter control allows the user to turn on and off a filter for surface waviness or curvature analysis. The control allows the user to adjust a slider bar or directly type a filter cut off value into the text box corresponding to that filter.
- Polynomial Filter: The Polynomial filter control allows the user to turn on and off a polynomial filter. When this filter is turned on, it finds step, removes the step from the data, ensures a low frequency fit to the data, removes the low frequency noise, and then re-creates the step.

Cursor Control – The Cursor Control arrows allow the user to move the cursors or widen the cursors in small increments

- R – This button activates the arrow controls for the Reference cursor
- M - This button activates the arrow controls for the Measurement cursor
- Right/Left Arrow Buttons – Left and right arrow buttons move the designated cursor to the right or left respectively each press of the button by the mouse cursor. The cursors do not move continuously if the button is held down.
- Up/Down Arrow Buttons – The up and down arrow buttons allow the user to widen or contract the designated cursor width for the Averaging Mode used in leveling the data.

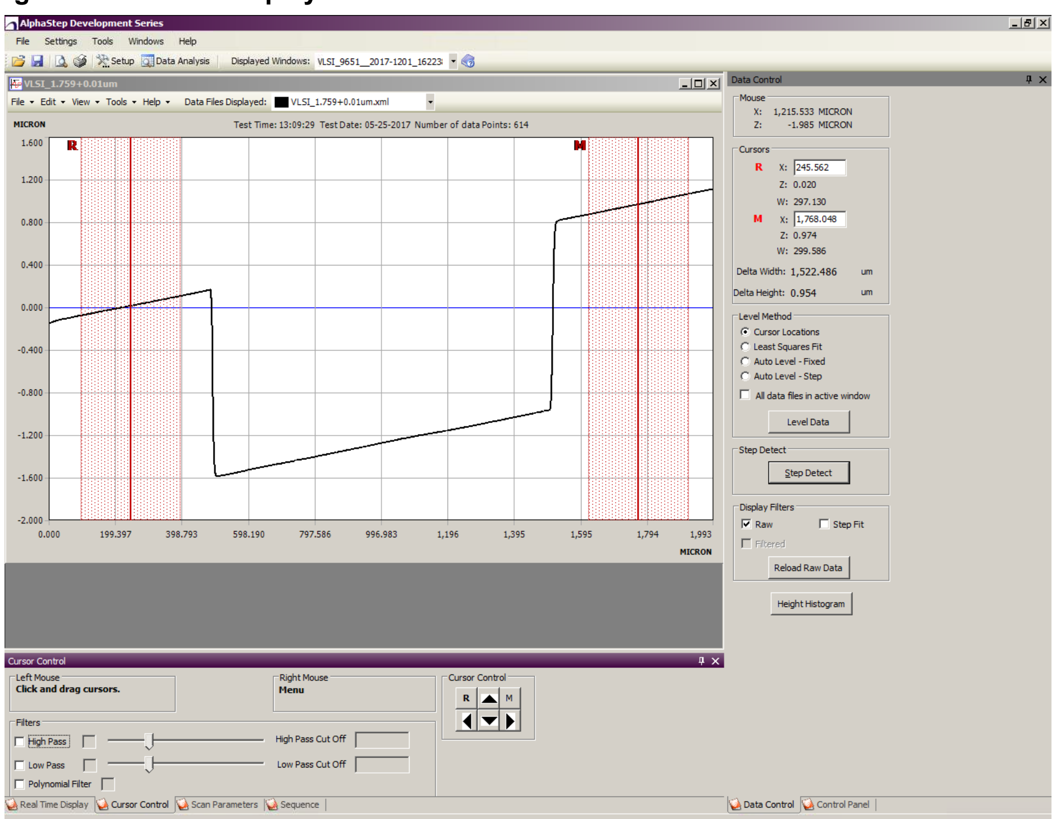
6.3 Leveling the Profile

If a surface to be measured is not parallel to the scan motion, the resulting trace is not be in level, causing inaccuracies in the analysis of the data. The Alpha-Step Development Series profiler provides two methods for leveling a profile:

- Software Leveling: The software has four methods of leveling. The user can manually level the data after a scan or the leveling can be set in the Setup parameters **Auto Features** tab to automatically level the profile by user specified parameters. The different software leveling methods are described as follows. Hardware leveling should be considered first to minimize software leveling artifacts.
- Mechanical Leveling: Mechanical leveling is discussed in Chapter 5, "Manual Stage Leveling," on page 77.

The Leveling cursors are used to define the data set used in the leveling operation. After a scan the **Data Display** window is displayed with displaying the profile and cursors located at the default locations. After a scan the data is as shown in Figure 6-13.

Figure 6-13 Data Display Window with Unleveled Profile



Before data analysis is attempted, it is often necessary to perform the leveling operation described in this section.

The data to be leveled using a linear rotational transform, which maintains the lateral positional accuracy. The baseline to be set using the average of the Z data contained within the R and M cursors.

To manually level a profile

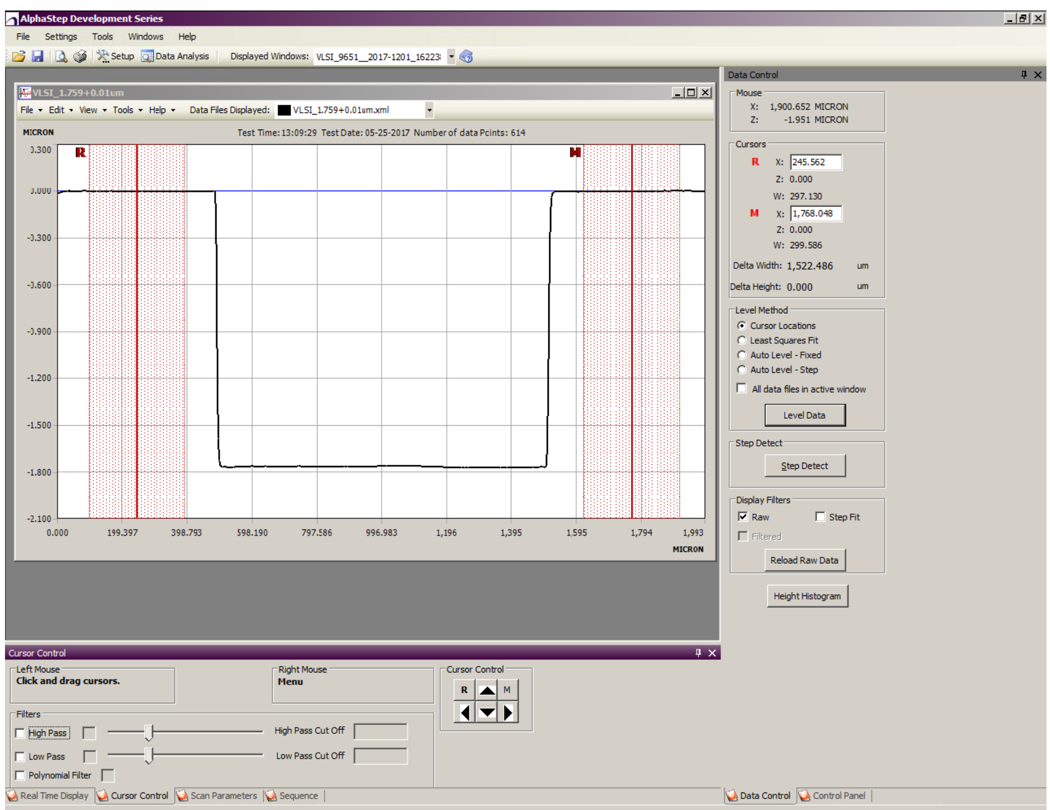
1. Drag the R (reference) pointer to the location on the profile that you wish to be the baseline for any measurement.
2. Use the mouse cursor, drag the M (measurement) pointer to the second location you wish to be the baseline for any measurement.
3. Click **Level Data** located in the Level Method box.

NOTE

Ensure that the Cursor Location radial button is active before leveling the data.

4. If desired, to undo the leveling use the mouse to click **Reload Raw Data**.

Figure 6-14 Profile After Leveling



Average Mode

The Leveling cursors can also be used in Average Mode. We define this mode as when the user expands the cursor width to include more of the profile data for use in leveling. Instead of a single vertical line, each cursor can be expanded to cover a section of the profile. When the cursor is expanded, a red shaded region represents the section of the profile that is included for averaging. Each cursor can be expanded separately and can have a different width. The values within this band are then averaged together and treated as a single point for the leveling calculation.

Figure 6-15 Average Mode for Leveling Profile (Demo)

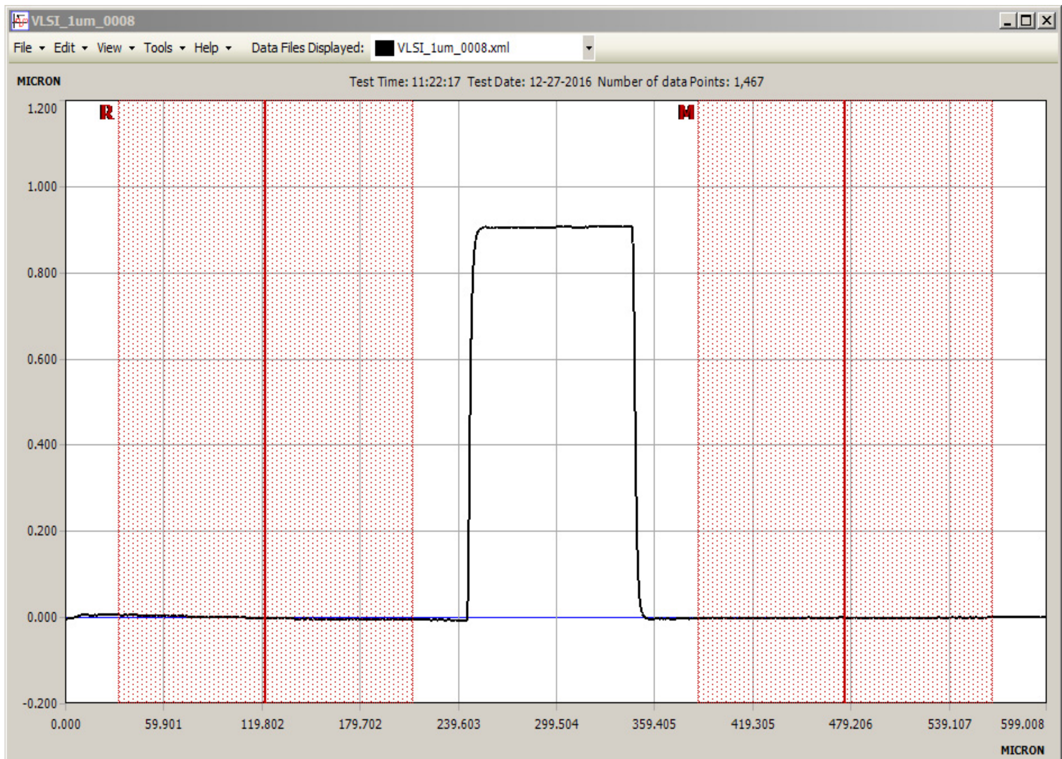


Figure 6-15 shows leveling of a profile where there are many sections that could be chosen but a single point would not be repeatable.

To level the profile in Average Mode using the mouse control:

1. Using the mouse, drag center line of the R (reference) pointer to the location on the profile that you wish to be the baseline for any measurement.
2. Using the mouse, drag the center line of the M (measurement) pointer to the second location you wish to be the baseline for any measurement.
3. Using the mouse, drag the hashed edge of the right or left side of the R pointer. Move the mouse to the right or left to expand or contract the area used for the Averaging Mode.
4. Using the mouse, drag the hashed edge of the right or left side of the M pointer. Move the mouse to the right or left to expand or contract the area used for the Averaging Mode.
5. Reposition the two R and M cursors, if necessary, to fine adjust the scan data you wish to use for leveling.
6. Click **Level Data** located in the **Level Method** box.

NOTE

Ensure that the Cursor Location radial button is active before leveling the data.

7. To undo the leveling, if desired, click **Reload Raw Data** and the software re-displays the profile as it was before leveling.

Using the Average Mode with the Cursor Control

1. Choose the R or M cursor button in the **Cursor Control** at the bottom right of the **Data Display** window. This activates the arrow keys for either the R or M cursor.
2. Use the mouse cursor and Alpha-Step on the up or down arrow key to expand or contract the designated cursor respectively. A single push of the button widens or narrows the cursor one pixel in the chosen direction. The button must be pushed each time to change the cursor rather than holding the button down continuously.

Auto Level - Fixed and Step

The **Alpha-Step Development Series** profiler software has two Auto Level features available to the user. Both of these leveling methods, Auto Level-Fixed and Auto Level-Step are defined in the Setup parameters **Auto Features** tab with user specified parameters (refer to Chapter 4, “Description of Features,” on page 23).

Auto Level-Fixed

1. Choose the Auto Level-fixed radial button in the Leveling Method box.
2. Press the **Level Data** Button, the profile is leveled using the predefined cursor positions set in the **Auto Features** tab found in the **Setup Control Panel**.

Auto Level-Step

1. Choose the **Auto Level-Step** radial button in the Leveling Method box.
2. Press the **Level Data** button. The profile is leveled using the Step Detect settings set in the **Auto Features** tab found in the **Setup Control Panel**.

6.4 Measuring Profile Features

After the profile has been leveled, the data is ready for critical examination. Following are the instructions for how to use the **Alpha-Step Development Series** profiler software features to make measurements on a profile.

Positioning the Cursors

The R and M cursors are also the measurement cursors. The user controls the cursors in the same manner as described in the leveling section above. The user can move the R and M cursors in one of two ways, using the mouse to position the cursor, or by using the Cursor Controls arrow keys in the **Data Display** window.

Positioning the Cursors for a Measurement using the Mouse

1. Move the pointer over the R cursor then drag the R cursor to the location on the profile that you wish to be the reference point.
2. Move the pointer over the M cursor and drag the M cursor to the location on the profile that you wish to be the second location measured relative to the reference point.
3. The Data Display shows the difference in Z and X position between the R and M cursors at any given time. The user can read these values from the Cursors control box (only for the main, red cursors) to get the height of a profile feature or the lateral distance of a profile feature.

Positioning the Cursors for a Measurement using the Cursor Control

1. Choose the R or M cursor button in the Cursor Control at the bottom right of the **Data Display** window. This is activates the arrow keys for either the R or M cursor.
2. Use the mouse cursor and click the right or left arrow key to move the designated cursor to the right or left respectively. A single push of the button moves the cursor one pixel in the chosen direction. The button must be pushed each time to move the cursor rather than holding the button down to move the cursor.
3. The Average Mode is available to the user for making a measurement as well as for use during leveling. It operates in exactly the same way as described in the Leveling section above.

Using the Average Mode using the Mouse control

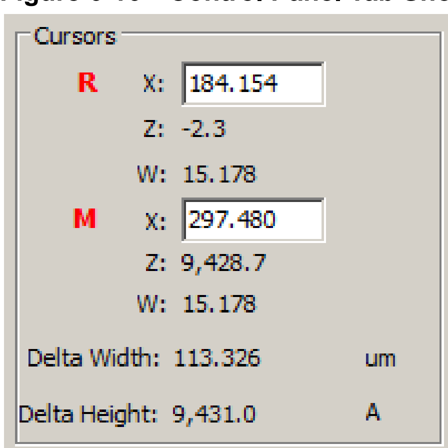
1. Position the cursors as explained in the “Average Mode” on page 99.
2. Move the mouse cursor to the right boundary of the M cursor, drag the pointer and expand it to a desired width.
3. Move the mouse cursor to the right boundary of the R cursor, drag the pointer and expand it to a desired width.
4. Position the M cursor on the step height or feature you wish to measure. The value is displayed in the Cursor Display box.

Using the Average Mode with the Cursor Control

1. Choose the R or M cursor button in the Cursor Control at the bottom right of the **Data Display** window. This is activates the arrow keys for either the R or M cursor.
2. Use the mouse cursor and click the up or down arrow key to expand or contract the designated cursor respectively. A single push of the button widens or narrows the cursor one pixel in the chosen direction. The button must be pushed each time to change the cursor rather than holding the button down continuously.

6.4.1 Reading the Cursor Data

Figure 6-16 Control Panel Tab Showing Cursor Data



NOTE

The profile is displayed and distorted by a much more sensitive scale on the vertical axis than on the horizontal axis. Do not try to estimate angles from the screen because angles that displayed to be significant on the screen might not be. There is a calculation feature in the software that calculates the angle or the slope for a section of the Chapter 4, “Calculation Settings,” on page 45.

The position of the measurement cursors is defined by the bold center line of each cursor with the intersection of the profile. If Averaging Mode is being used, the features to be measured from the cursor center-line and not from one of the edges.

As you move the cursors, measurement data is continually updated in the Cursor Box to the upper right of the profile graph. The following values are displayed in the Cursor Box:

X: (millimeters) Horizontal position of the mouse cursor along the scan axis.

Z: (Angstroms) Vertical position of the mouse cursor along the height axis.

R: Reference cursor information

X: Horizontal position of the reference cursor along the scan axis.

Z: The height of the profile at the intersection of the reference cursor and the scan.

W: Width of the R cursor shaded region

M: Measurement cursor information

X: Horizontal position of the measurement cursor along the scan axis.

Z: The height of the profile at the intersection of the measurement cursor and the scan.

W: Width of the M cursor shaded region

Delta Width: Horizontal (X) distance between cursors (in Average Mode, the horizontal distance between the center-line of the two cursors).

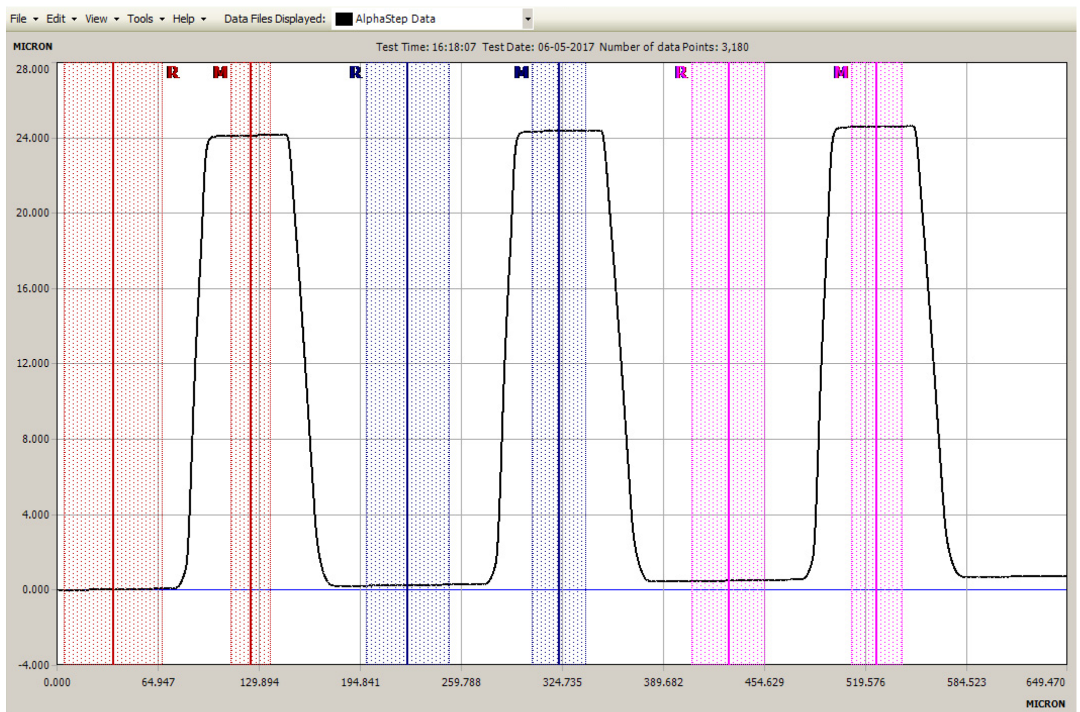
Delta Height: Vertical (Z) distance between profile intersections of the R and M cursors (in Average Mode, the vertical distance between the average values of height within the two averaged regions).

To select the units for the cursor data display, select **Units** from **Settings** drop-down list. You can change the scan display units in either metric or English units. The scale controls allow the X-Y scaling to be set separately from the Z scale. For more information about unit setup, refer to Units on page 30.

Adding Additional Cursors

Additional cursors can be added to the **Data Display** window allowing multiple feature measurements. Each additional cursor set is displayed in a different color. Up to four additional cursor pairs can be added for a maximum of five cursor pairs in the display. The additional cursors make the calculation measurements on the section of the profile between the Matching R and M cursors.

Figure 6-17 Data Display Window with Multiple Cursor Pairs



NOTE

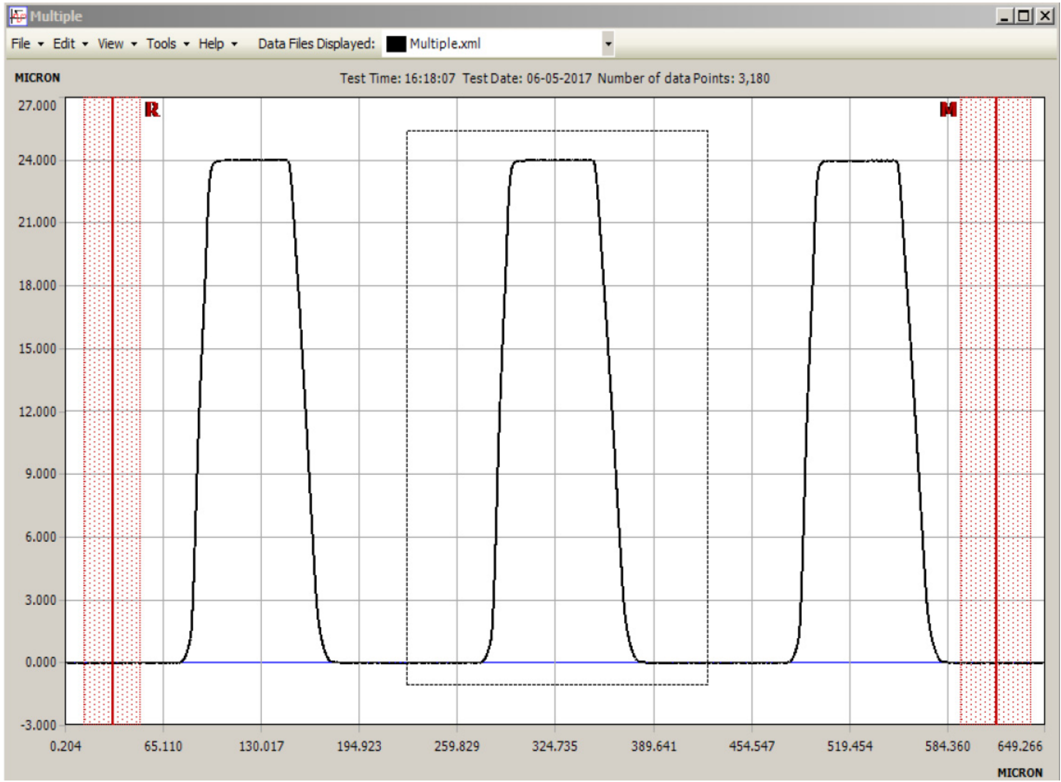
Only the Red Primary Cursors can be used to level the profile. The added cursor pairs are used in the calculations only. Each cursor pair has different color.

To add additional cursors

1. From the **Data Display** window right-click to open the functions menu.
2. Select the Add Cursor option.
3. A new set of R and M cursors are displayed in the **Data Display** window.

To add additional cursors, repeat the above directions. The cursors can be sized and moved the same as the initial R and M cursors.

Figure 6-18 Data Display with Zoom Box for Data Zoom

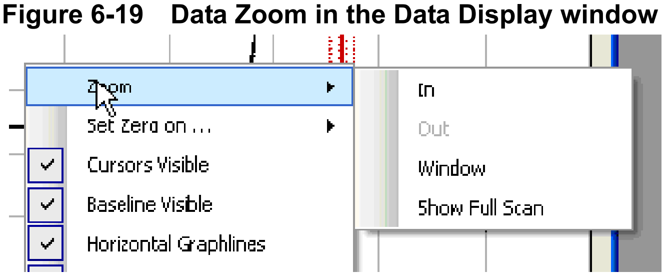


Data Zoom in the Data Display window

There are multiple Zoom options available to the user. You can use the **In** function or the **Window** function to activate a zoom box in the **Data Display** window.

Zoom In - Is reducing the horizontal display by 50%. The **Zoom In** function can be used repeatedly to visualize smaller features and see higher resolution information.

Figure 6-19 Data Zoom in the Data Display window



Zoom window - Displays a green box in the Data window. The user can position the box over any part of the profile, expand or shrink the box and re-display the data set contained in the box expanded in the **Data Display** window. After the area of interest is chosen, right-click to redraw the zoomed area in the Data window or Cancel the operation all together.

Following is a brief tutorial of how to use the Zoom functions with figures for clarification.

To use Zoom In

1. From the **Data** window, right-click to open the Alternative drop-down list.
2. Use the cursor to select the Zoom options; this displays the **Zoom** drop-down list.
3. Click **In** option.

To open the Zoom Box

1. From the Data window, right-click to open the functions menu.
2. Select the **Zoom** option to open the Zoom drop-down list.
3. Click **Window**. A green Zoom box is displayed in the **Data Display** window.

To reposition the box

1. Position the mouse cursor inside the Zoom box.
2. Click and hold the mouse button, a four arrow cursor is displayed.
3. Move the mouse to reposition the Zoom box over a section of the profile you wish to magnify.
4. Release the mouse button.
5. Right-click to Zoom. The boxed data set is expanded in the Display screen.
6. Repeat the above steps to Zoom into another feature of interest.

To display the Zoomed Data

1. While the zoom box is active in the Data window, right-click again to open a menu to accept or cancel the zoom area.
2. Select the **Zoom** option to display the new magnified view of the profile section.

6.4.2 Calculation Setup

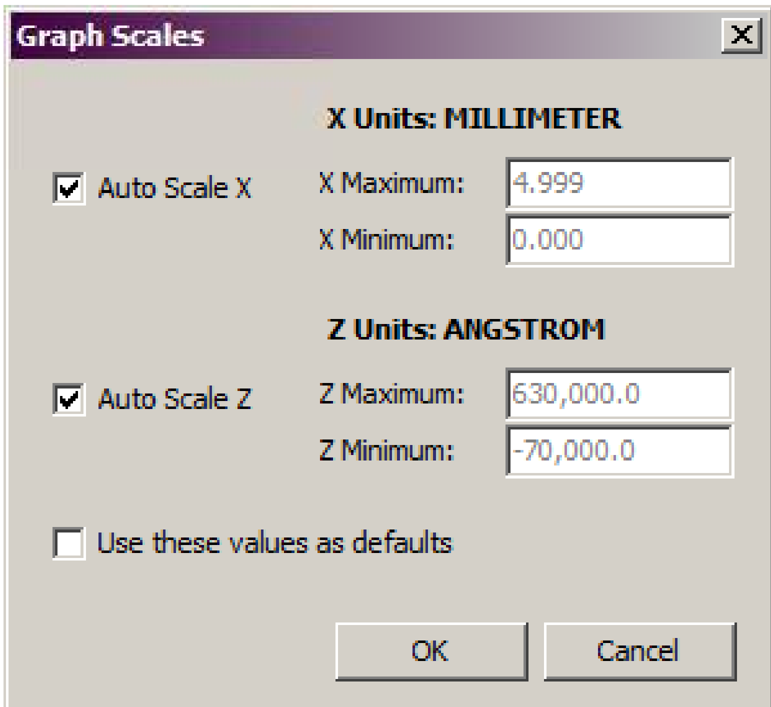
A number of physical parameter calculations such as step height, slope, angle, radius, roughness parameters and so on are available in **Data Analysis** tab.These results are computed for either the specific **Data** window or globally for all the open **Data** windows.

You can make calculations on Raw profile data, Low pass filter for Waviness calculations and the High pass filter for Roughness calculations. For details about the calculation settings, refer to Chapter 4, “Calculation Settings,” on page 45.

6.5 Scaling Data

The **Graph Setup** window allows the user to set the display axis for profiles. In cases where various profiles need to be compared directly it is easier to make the comparison using identical axis scales. This tool allows the user to choose the scale for data display needed for easier comparison. The default setting is Auto Scale in both X and Z.

Figure 6-20 Graph Setup Window



To display the Graph Setup window

1. From the **Data Display** window, right-click to open a drop-down list.
2. Select Set Graph Scales and the **Graph Setup** window is displayed.

To change the Scale

1. Deselect the check boxes for Auto Scale.
2. Type a number in the X Maximum field.
3. Type a number in the X Minimum field.
4. Type a number in the Z Maximum field.
5. Type a number in the Z Minimum field.

NOTE

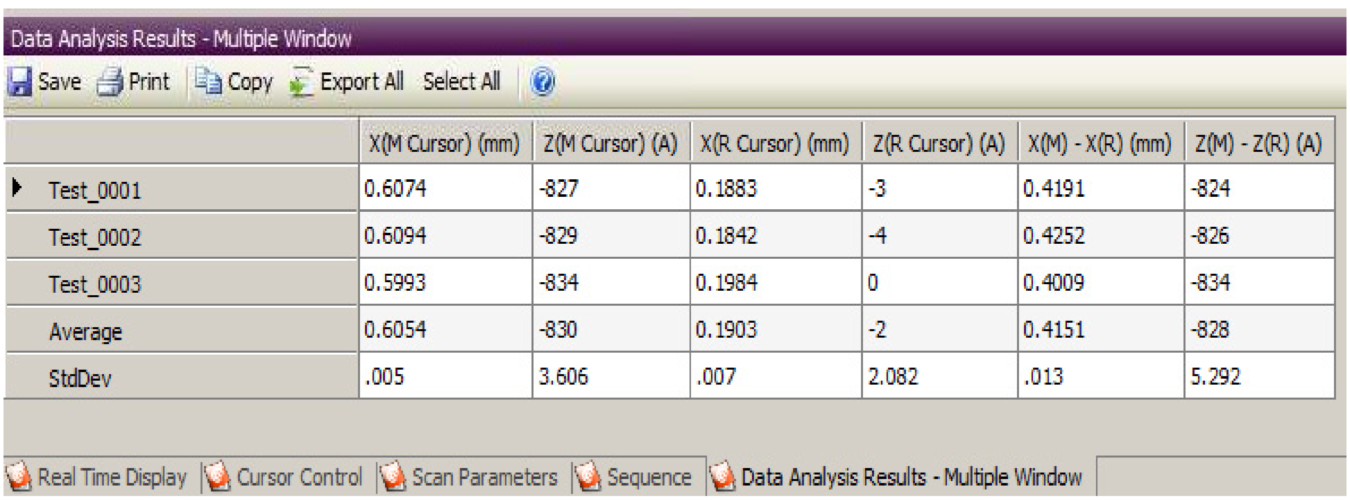
If the user would like to use the new graph scale values for more than one scan, select the Use these values as defaults check box. Otherwise the graph scales can be set to the default auto scale for any additional scans.

6. Click **Ok** to apply the new settings and close the **Graph Setup** window.

6.6 Data Analysis Tab

The **Data Analysis** tab is where the calculation results are displayed. The tab can be set to a window as described in the previous section (Chapter 4, "Scan Parameter Tab," on page 42). The **Data Analysis** tab presents the calculation results for any Data windows that are displayed. If the user selects to calculate for the active Data window, then only the results for that window are presented. A tutorial for making calculations on a single Data window or with multiple Data windows is given as follows.

Figure 6-21 3 Profiles loaded in Data Display Window



	X(M Cursor) (mm)	Z(M Cursor) (A)	X(R Cursor) (mm)	Z(R Cursor) (A)	X(M) - X(R) (mm)	Z(M) - Z(R) (A)
Test_0001	0.6074	-827	0.1883	-3	0.4191	-824
Test_0002	0.6094	-829	0.1842	-4	0.4252	-826
Test_0003	0.5993	-834	0.1984	0	0.4009	-834
Average	0.6054	-830	0.1903	-2	0.4151	-828
StdDev	.005	3.606	.007	2.082	.013	5.292

Figure 6-21 shows the results for a single data window with 3 profiles loaded. The average and standard deviation are also displayed with the results.

6.6.1 Data Analysis Tab Features

Tool Bar Description

Figure 6-22 Tool Bar Description

Save – Opens the standard **Save** dialog box. The results are saved as a text file.

Print – Opens the standard **Windows Print** dialog box to choose a printer. The action prints the results in a table form.

Copy – When the user highlights any of the rows, columns, or cells of the results, clicking **Copy** saves a copy to the Windows clipboard.

Export All – Pressing this button exports all the information in the **Data Display** tab and **Scan Parameters** tab in csv format. It also records current time, tool and operator information.

Select All – Pressing this button causes the software to highlight all the rows and columns in the **Data Display** tab making it easy to then copy or export the values to another program like a spreadsheet.

Help – Opens the help files for the **Alpha-Step Development Series** profiler application.

6.6.2 Using the Data Analysis Tab

After the user selects the parameters in the **Calculations** window and chooses to analyze the profile, the results are presented in the **Data Analysis** tab. The software calculates the selected parameters between the R and M cursors. If additional cursors are used, the results for each of these cursor sets are displayed with the corresponding color of the cursor in the **Data Analysis** tab as well. There are several ways to open the **Data Analysis** tab.

NOTE

*To open the **Analysis** tab with any of the methods described in the followings it requires the user to have selected at least one parameter in the Calculation Control.*

To display the **Data Analysis** tab from the Data window

1. From the Data window, select the **Tools** drop-down list.
2. Click **Data Analysis**.
3. The software calculates the selected Calculation parameters set in the **Calculations** window.

To display the **Data Analysis** tab from the **Application** window

1. From the **Application** window, select the **Tools** drop-down list.
2. Click **Data Analysis**.
3. The software calculates the selected Calculation parameters set in the **Calculations** window.

In the case where multiple Data windows are open and the user wishes to display results for all of the open windows:

1. From the **Application** window, select **Data Analysis** from the toolbar.
2. The software calculates the selected Calculation parameters set in the **Calculations** window.

NOTE

*The **Data Analysis** tab displays the Average and Standard deviation of the parameter results from all the profile data from all the open Data windows.*

6.7 Saving and Exporting Calculation Results

The **Alpha-Step Development Series** profiler Application has several ways the user can save and export Analysis Results. In all windows, tabs and the **Application** windows, the user can use standard Microsoft Copy and Paste functions to the Clipboard to then enter results, graphics and annotations to a spreadsheet or other presentation software.

In this section we can discuss how to use the Application features to save or export analysis results.

6.7.1 Printing Calculation Results

After you have displayed the **Results** window, by using the Calculate Results feature, these results can then be printed.

1. Select **Print** in the **Results** window.
2. The software displays the Windows **Printer** dialog box for your default printer.
3. Click **OK** or the press **ENTER** to print the results.
4. Close the **Results** window to return to the **Data Display** window.

6.7.2 Printing the Profile

1. From the **Data Display** window, click the **File** drop-down list.
2. Click the **Print** menu. The Printer dialog box is displayed.
3. Select **Print** or press **ENTER** to print.

6.7.3 Printing using the Screen Capture Function

The **Alpha-Step Development Series** profiler software supports the Microsoft Operating System Print Screen function. This feature allows the user to capture a screen image of the current monitor screen view or of the active window view and save the image to the clipboard. The user then can paste the screen capture image to any graphic program or word processor program that accepts the format.

6.7.3.1 Full Screen Capture

1. After you have displayed the profile, Results, or any part of the **Alpha-Step Development Series** profiler software, simultaneously hold down the **PRINT SCRN**.
2. The monitor screen view window is saved to the **Clipboard**.
3. Use the Paste function to place the Clipboard image into a word processor or graphics editing program (**CTRL-V**).
4. The image is copied into the open word processor or graphic program.
5. The image is ready to make any annotations, captions, or include in a presentation.

6.7.3.2 Active Window Screen Capture

1. After you have displayed the profile, Results, or any part of the Alpha-Step **Development Series** profiler software, simultaneously hold down the **CTRL-ALT-PRINT SCRN** keys.
2. The Current window is saved to the Clipboard.
3. Use the Paste function to place the Clipboard image into a word processor or graphics editing program (**CTRL-V**).
4. The image is copied into the open word processor or graphic program.
5. The image is ready to make any annotations, captions or include in a presentation.

6.7.4 Saving Data

From the Main Software window

1. Click the **File** drop-down list in the top left corner of the screen.
2. Click **Save Data File**. A dialog box is displayed.
3. Type the name of the file you want to save in the dialog box and press **ENTER**.

From the Data Display window

1. Click the **File** drop-down list in the top left corner of the **Data Display** window and click **Save As**.
2. Enter the file name to save in the **Save A**s dialog box and press **ENTER**

6.8 Software Filter Settings

The **Alpha-Step Development Series** profiler software enables you to separate the waviness and roughness components of your data by selecting a **Cut Off Filter**. The filter controls are located on the **Cursor** tab. The **Filters** provide an adjustable short wave cutoff filter allowing you to isolate wavelengths. The cut off filters are:

- Short wavelength filter cut off, known as **High Pass**
- Long wavelength filter cut off, known as **Low Pass**

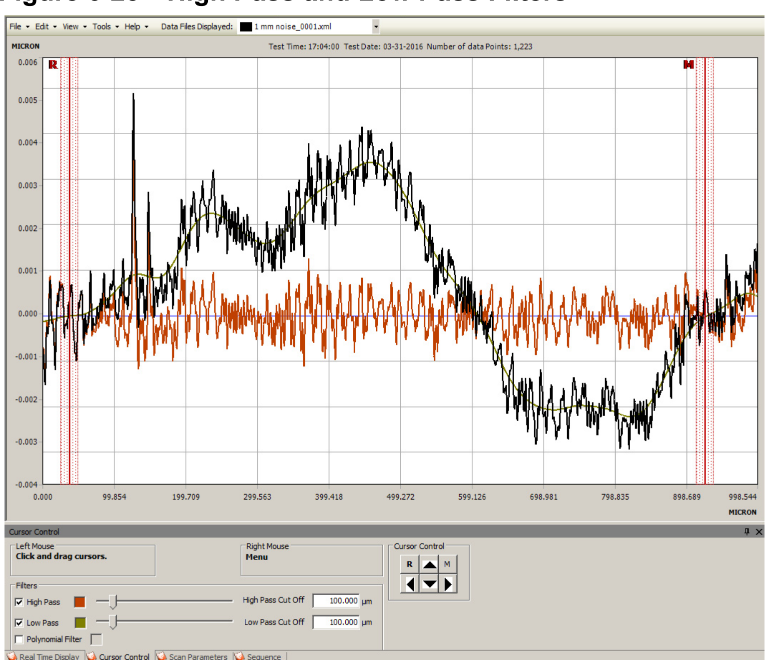
Besides, this a **Polynomial Filter** is provided, which removes the low frequency noise and improves the step height repeatability

6.8.1 Using Cutoff Filters

The software **Band Pass Filters** are controlled by the user choosing a cut off value. This cut off value is then used in the High Pass or Low Pass filter algorithm. The filtered data is displayed in a different color to the raw profile data. The user can choose to display only the filtered data, both the filtered data and the raw data, or only the raw data using the radial buttons in the lower right corner of the **Data Display** Window. A description of setting the software filters is given as follows.

Figure 6-23 illustrates the isolation of the roughness on the surface of the bump from the curve. The orange profile shows the High Pass filter and the olive green profile shows the Low Pass filter. Original profile is shown in black.

Figure 6-23 High Pass and Low Pass Filters



Select the High Pass filter, Low Pass filter or both filters, click the corresponding check box. Checking a Filter box displays a colored profile of the filtered scan data in the Graph Display that matches the color box to the right of the filter type Check Box (see Figure 6-17).

To adjust the Cut Off Filter Level

Use the mouse to highlight the number in the filter cut off text box for the filter type you are using. Type a number into the text field and press the **ENTER** to recalculate the filter value and refresh the profile display.

-or-

Drag the pointer on the slider bar and move the slider right or left to adjust the cut off value of the filter.

The number displayed in the text box is the length value that the High Pass or Low Pass filter in use to calculate the filtered profile. Using a larger number for the Filter Cut Off value can correlate to larger features being filtered, which also corresponds to lower frequencies. Using a smaller number value in the Filter Cut Off value can correlate to smaller features being filtered, which also corresponds to higher frequencies.

6.8.2 Using Polynomial Filters

When Polynomial filter is enabled, it finds step, removes the step from the data, ensures a trinomial fit to the data, removes the low frequency noise, and then re-creates the step. The filtered data is displayed in green while the raw profile data is in black. This filter improves the step height repeatability.

6.8.3 Using Step Fit

This function is located on the **Data Control** panel, rather than the **Cursor Control** tab. When it is enabled, the data is fit with a periodic rectangular profile that slopes linearly up or down. The output parameters for Period step are: Period, Duty Cycle, and Height. The duty cycle is expressed as the ratio of the length of the high segment of the period to the length of the low segment. The goodness-of-fit criterion used in the curve fit is the least absolute error, not the least squares error. The Periodic Step fitting algorithm produces meaningful results only if it is applied to section data that has a truly periodic contour, or if it is applied to single surface step, which can be interpreted by the software as a segment of a longer periodic contour.

7

Advanced Features

Contents

7.1 Introduction

This chapter describes the advanced features available in the **Alpha-Step Development Series** profiler Application software. The chapter gives a tutorial to guide the user through setting up and using these advanced features.

NOTE

3D scanning and Sequence Scans are only available for D-600 which has the motorized stage.

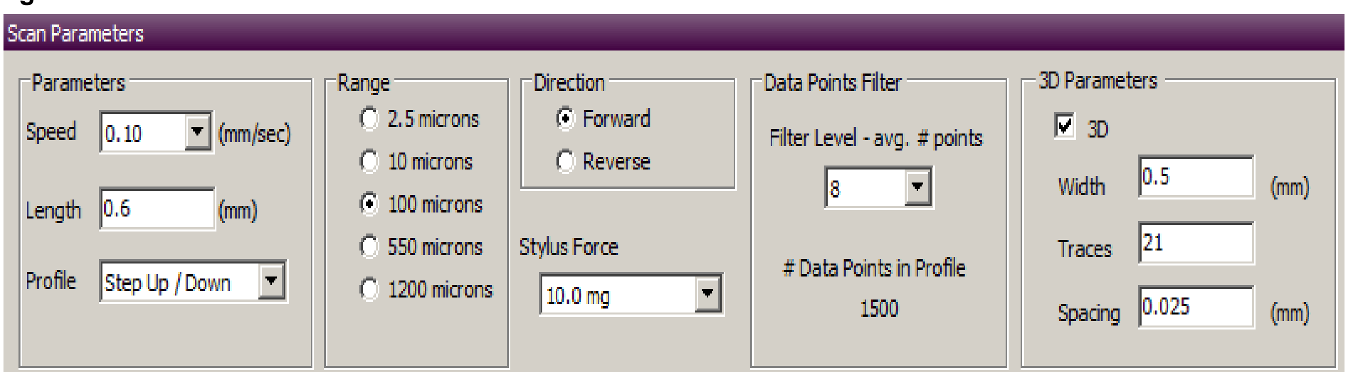
7.2 3D Scanning

3D scanning enables measuring the topology of an area with many individual scans. The individual scans are combined together to form a 3D image. The data for 3D scanning is saved as an .AMB file and can only be viewed in the Off-Line software Apex. 3D scanning is for the Alpha-Step D-600 profilers only.

7.2.1 Setting up and Running a 3D Scanning

1. Select the **Scan Parameters** tab.

Figure 7-1 Scan Parameters Tab



2. Set up the scan parameters for the individual scans including scan **Speed**, scan **Length**, **Profile** type, scan height **Range**, scan **Direction**, **Stylus Force** and **Filter Level**. Refer to "Chapter 4, "Scan Parameter Tab," on page 42 for the definition of these parameters.
3. Select the **3D** option to enable the 3D scanning.
4. Type the **Width** of the scan area

5. Type the number of **Traces** of the 3D scan. If either the value for Width or Spacing is changed, the traces are updated automatically.
6. Type the **Spacing** between the traces. If the value of the number of traces is changed, the spacing is updated automatically.
7. Click **Scan** in Video Capture to start the 3D scan. A pop-up window is displayed to select a directory and enter a file name for the 3D scan.
8. After the scan is finished, the result is saved in the selected directory. At the same time, Apex automatically starts and opens the 3D result. If Apex is already open and has data inside, the new 3D result appends at the end of the Apex file.

To save or load the 3D recipe, it is performed the same way as explained in Chapter 4, "Using Scan Recipes," on page 52.

7.2.2 Viewing a 3D Data File

Viewing a 3D file requires using a third party software package, Apex, sold with the 3D option. After a 3D scan finishes, the computer saves the 3D data as .AMB file, and at the same time, automatically opens Apex and sends the result to Apex. Apex can be also used to analyze saved 2-D or 3-D Data.

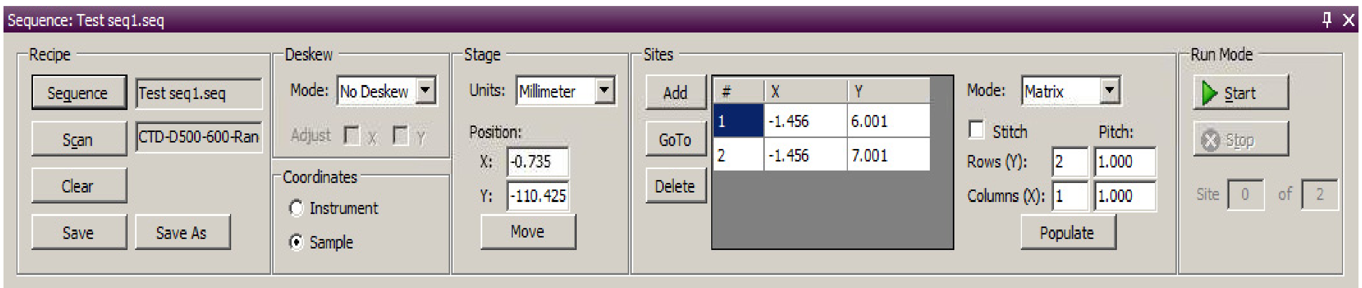
1. Double-click the **Apex** icon on your desktop or start the program from the Windows **Start** menu.
2. Select the **File** drop-down list or use the Open a Studiable icon on the tool bar of the Apex software screen.
3. Navigate to the **Data** folder, or the folder that the 3D file you are interested in viewing is located.
4. Select the file you want to open and the 3D top view of the data is displayed in the window.
5. Click **Open**.
6. The data is displayed in Apex.

7.3 Sequence Scans

Sequence scanning is available for Alpha-Step D-600 profilers only. It enables the user to take advantage of the motorized stage to program multiple 2-D or 3-D measurements to make statistical measurements on a sample. The saved sequences have file extension of .seq or .stp.

7.3.1 Sequence Control Panel

Figure 7-2 Sequence Control Pane



Recipe

Sequence – This button opens the saved Sequence Recipes folder from which an already saved sequence recipe can be loaded for use. The name of the loaded sequence is displayed in the box next to the sequence button. If a new sequence recipe is built and saved, the sequence name is also displayed in the box next to the sequence button.

Scan - This button opens the saved scan Recipes folder from which an already saved scan recipe can be loaded for use in the sequence scan. When a sequence recipe is loaded, the associated scan recipe is automatically loaded. The user can change the scan recipe used in the recipe by loading a new scan recipe. The scan recipe name is displayed in the box next to the scan button.

Clear – This button clears or sets all the fields to default values in the Sequence Control Pane.

Save – This button saves the changes made to the current sequence. This button is disabled if the sequence is new. If any change is made to a loaded sequence recipe, the user must first save the recipe to run the sequence.

Save as – This button opens a window to ask the user to save the current parameters in the Sequence pane as a new sequence recipe in a user defined folder.

Deskew

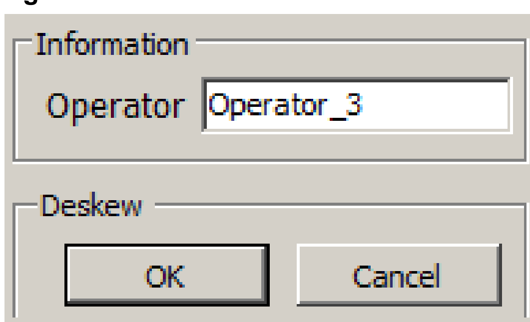
Mode – There are two modes for Deskew: No deskew or single site deskew. The default is No Deskew. If No Deskew is selected, the sequence scan is directly executed with the sites list. If single site deskew is selected, all the scan sites are recalculated during the sequence scan with respect to the adjustments to the deskew site:

- Adjust X: if this is selected, the X-coordinate of the deskew site is used as the X-coordinate of the first scan site, and the X-coordinate of all the other sites are adjusted the same way as the first site.
- Adjust Y: if this is selected, the Y-coordinate of the deskew site is used as the Y-coordinate of the first scan site, and the Y-coordinate of all the other sites are adjusted the same way as the first site.

Steps to do a sequence scan with Deskew function enabled:

1. Active the Sequence Control pane, load or setup a sequence recipe.
2. Click **Start**, under **Run** Mode to start the sequence recipe.
3. After selecting the folder and entering the file name to store the data, with the popup window, the Deskew function is displayed at the bottom of the Control Pane.

Figure 7-3 Deskew Confirmation Function in Control Pane



4. The stage then moves to the first scan site, focuses on the sample and then lifts up the stylus.
5. Navigate the sample to a new location that is the deskew position for the Sites List.
6. Click **OK**, see Figure 7-3, to accept the current stage location as the Deskew site. Then the sequence scan starts.

   -or-

7. Click **Cancel** to quit the Deskew function. Click **Stop,** under **Run** Mode to stop the sequence scan or move the stage to a new location and the Deskew function is available again.

Coordinates

Instrument – All the coordinates in the Sequence pane use the instrument as the reference. The 0,0 of the coordinate is the home position of the X-Y stage.

Sample - All the coordinates in the Sequence pane use the Sample reference. The 0,0 of the coordinate is the center of the sample chuck.

Stage

Units - The user can select the units for display for the X- and Y-values in Sequence Control Pane. The default units are in Millimeters, the other choice is Inches. Toggling the units automatically re-displays all X, Y values in the sequence control pane in the new unit type.

Position – During the stage movement, the X- and Y-values display the stage position and are updated simultaneously as the stage moves. The user can also input new coordinates in the X and Y text boxes by clicking **Move**, and then the stage moves to the input position. If the user simply inputs new coordinates without clicking **Move**, the input values are kept until the user changes it or the stage moves.

Sites

Sites Table – This shows the sites used for the sequence scan. If the Mode is Discrete, the user can modify the X-Y coordinate of any selected site individually. If the Mode is Matrix, only the first X-Y site value is editable, and the sites coordinate in the sites list can be updated with the first X-Y site coordinate together with the parameters in Matrix Mode.

Add – For Discrete Mode, this adds a new site to the Sites Table next to the selected site in the Sites Table. The new added site uses the current stage coordinates as its X-Y coordinate. For Matrix Mode, the Add function is creates a new Sites Table with the current stage coordinate as the first site coordinate together with the parameters in Matrix Mode.

Goto – Selecting a site in the Sites List and clicking **GoTo** drives the stage to the selected site.

Delete – If the Sites Mode is discrete, the **Delete** button deletes the selected site from the Sites List. If the Sites Mode is Matrix, clicking **Delete** is deleting all the sites: a window is displayed telling the user the sequence is a matrix and asking whether the user wants to delete all the sites.

Mode - This defines the sequence to be Matrix or Discrete sequence with the drop-down selection.

- Discrete - If this is selected, the sequence can be a discrete sequence. All the following parameters Mode can be disabled, and the user can add or edit any site individually. If the Sites Table is created using Matrix Mode, changing Mode from Matrix to Discrete keeps these sites.
- Matrix - This defines the Sites list is in a Matrix type. Changing Mode from Discrete to Matrix is creates a new Sites Table with the first available site together with the parameters in Matrix Mode.
- Rows (Y) - The user needs to define the number of rows and the pitch between the adjacent rows for the Sites matrix.
- Columns (X) - The user needs to define the number of Columns and the pitch between the adjacent columns for the Sites matrix.
- Stitch -This option can be available only when the scan recipe is a 2-D scan recipe. If this option is checked, the tool can scan up to ten individual scans and then stitch the profiles together to form a long profile. In this way, the scan length can be extended to full 200 mm, instead of 55 mm scan length for a single scan. If the scan length of the 2-D Scan Recipe used in the Sequence is bigger than the input pitch size, there can be some overlap of two consequent scans, and the overlapped region can be used to stitch. If the scan length is bigger than the pitch size, there is no overlap between consequent scans. The individual profiles are simply added together to form a long profile.
- Populate - If there is no site in the Sites table, this creates the matrix sites list using current stage coordinates and Matrix parameters. If there are sites in the Sites table, this is updating the sites table using the first site in the Sites table and the Matrix parameters.

Run Mode

Start – Clicking this button executes the sequence scan. A displayed window is asks the user to select the folder and input file name to store the sequence files. If any change is made to the Deskew or the Sites List in the sequence recipe but not saved, an error message is displayed and ask the user to save the recipe before running it.

Stop – This button stops the sequence execution and is only available after the sequence scan has started.

Site – During the sequence scan, this shows the user the current scan sites number relative to the total sites number.

7.4 Stitch Pre-Saved Data

The stitch option in the Sequence Pane stitches the data during the Sequence Scan. There is another stitch feature under Tools Functions that enables the user to stitch scan data any time. These scan data do not need to be from the sequence scan. This feature allows the user to stitch the scan profiles after the scan finishes. The individual profiles that are stitched together must have the same data resolution or the software is not be able to combine them and an error message is displayed.

7.4.1 Opening the Stitch feature

To start the Stitching feature from the Main software screen:

1. With the mouse cursor, select the **Tools** drop-down list at the top left corner of the Main software screen.
2. Select the **Stitch** option.

The Stitch control panel is displayed.

An alternate method for starting the Stitch feature:

1. From the Main software screen, press the **ALT + T** keys to open the **Tools** drop-down list.
2. Press **S** to open the Stitch function.

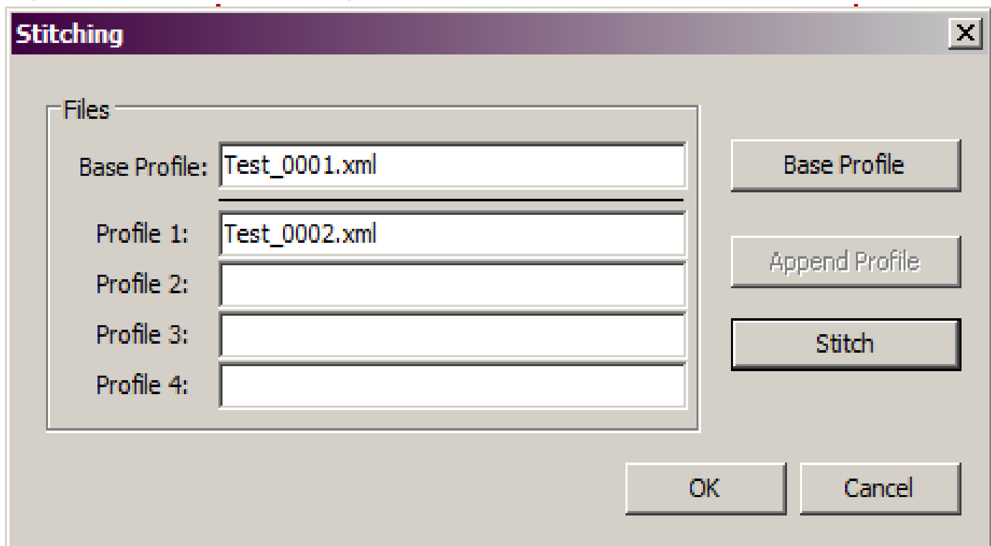
To start the Stitching feature from the Data Display window:

1. With the mouse cursor select and click the **Tools** drop-down list at the top left corner of the Data Display window.

The Stitch control panel is displayed.

7.4.2 Stitch Control Panel Description

Figure 7-4 Active Stitching windows



Stitching – This panel allows the user to add multiple profiles together to make a single larger profile up to 400,000 data points. The profiles being added must have the same data point spacing though they do not need to have the same length.

Base Profile – This button opens a **Load Data** window. The user selects the profile for the base or first profile to which the other profiles can be added. The data file is loaded into the software.

Append Profile – This button opens a **Load Data** window. The user selects the profile that can be added to the end of the base profile. The two data files are loaded into the software.

Stitch Button – This button runs the algorithm to add the Appended profile to the Base profile or the previously combined profiles if more than two profiles are being added together.

Figure 7-5 Data window with Stitched Composite Profile

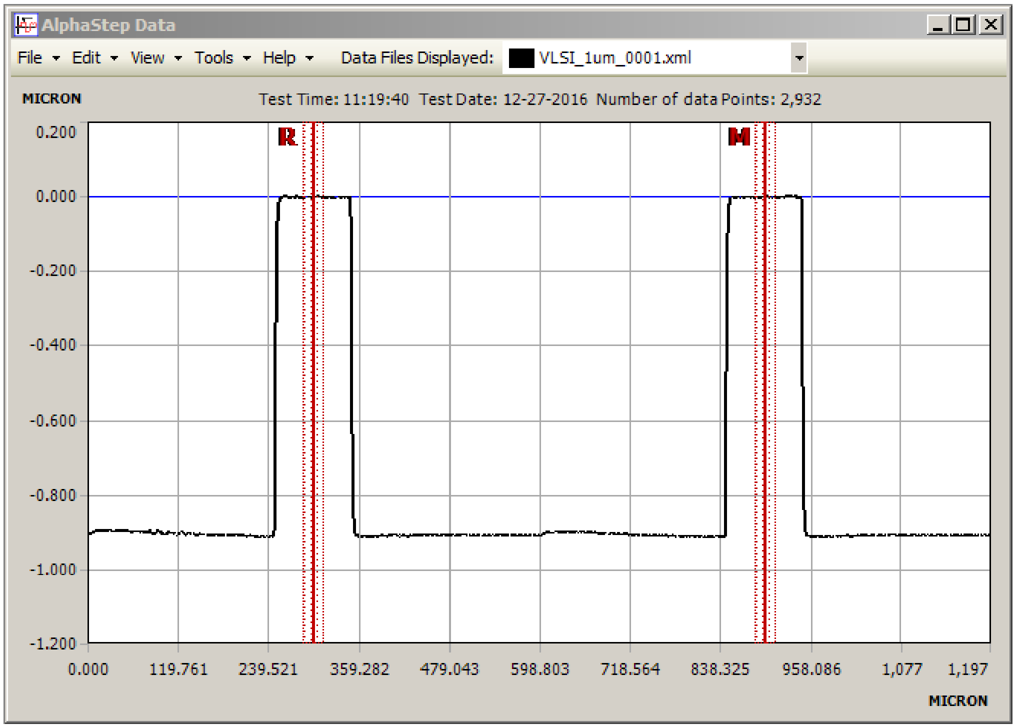


Figure 7-5 shows the Data window with a stitched composite profile after adding 2 of the same profile end to end.

7.4.2.1 Stitching

1. Open the **Stitch Control Panel**.
2. Press the **Base Profile** button to load the first profile. A Load Data window is displayed.
3. Choose a profile that is the first profile of the composite profile and click **OK** to load the profile data into the software.
4. Click **Append Profile** in the Stitch control panel. The Load Data window is displayed.
5. Select the profile that is the second profile in the composite profile and click **OK** to load this profile data into the software.
6. Select **Stitch** on the control panel. This adds the second profile onto the end of the first profile loaded as the Base Profile.
7. Repeat step 5 and step 6 for each additional profile you wish to stitch together. The software allows up to five profiles to be stitched together.
8. After you have finished loading and stitching all the profiles together, click **OK** to close the **Stitch Control Panel**.

7.4.2.2 Displaying the Stitched Profile

From the Main software screen:

Click **Analysis** to open the Data Display window. The composite profile is displayed in the graph area.

From the Data Display window:

The composite profile is displayed in the Data Display after closing the **Stitch Control Panel**.

7.4.3 Multiple Scans

The **Alpha-Step Development Series** profiler software allows the user to display up to 10 profiles overlaid in a single Data Display window. The profiles must all have the same number of data points and the same scan length to be displayed together. This feature is designed to operate closely with the Stepping feature so the user can load many profiles simultaneously and compare them. Additionally, loading multiple files improves the instrument efficiency by allowing the operator to make measurements more quickly.

7.4.3.1 Using the Multiple Scan Feature

At the top of the Data Display window is a File Name box. Each profile loaded into the software has a color associated with it. This box shows the file names of the profiles loaded into the software and a color square that matches the color of the profile in the Data Display graph. The profile displayed at the top of the File Name drop-down list is defined as the Profile in Focus. Only the profile in Focus can be analyzed with the cursors and calculations results presented. The user can select a different profile at any time and choose a calculation without having to realign the cursors or change the setup. The procedure is described as follows:

Loading Multiple Data Files

1. With the mouse cursor select the **File** drop-down list at the top left corner of the Data Display window.
2. Select the **Load Data File** option. The Load Data window is displayed.
3. Go to the data folder of interest and select the first file you wish to load by clicking once to highlight the file.
4. Loading consecutive and non-consecutive data files:

    To load consecutive data files, hold the **SHIFT** at the same time as you click the last data file you wish to load. All the files in between the first and last file selected are highlighted.

    To load non-consecutive files, hold the **CTRL** at the same time as you click a file. This highlights that file and allows you to also select and highlight additional data files.

5. Press the **Open** button to accept the choices. The **Load Data** window is closed and the selected profiles are loaded into the Data Display window.

NOTE

Up to 10 profiles can be loaded at one time. All of the Data files must have the same scan parameters or an error message is displayed. Clicking on the error message box closes the message and the data file is skipped from loading. All the data files chosen are loaded in the order they are displayed in the data folder alphabetically. The data files must all match the first file loaded.

Adding Additional Profiles to the Data Display window

1. Click the **File** drop-down list at the top left of the **Data Display** window.
2. Click the **Add Data File** option. The **Load Data** window is displayed.
3. Go to the data folder of interest and select the first file you wish to load by clicking once to highlight the file. If you are only adding 1 data file, skip to step 5.
4. Loading consecutive and non-consecutive data files:
   - To load consecutive data files, hold the **SHIFT** at the same time as you click the last data file you wish to load. All the files in between the first and last file selected are highlighted.
   - To load non-consecutive files, hold the **CTRL** at the same time as you click a file. This highlights that file and allows you to also select and highlight additional data files.
5. Press the **Open** button to accept the choices. The Load Data window is closed and the selected profiles are loaded into the Data Display window.

NOTE

Up to 10 profiles can be loaded at one time. All of the Data files must have the same Setup parameters or an error message is displayed. Clicking on the error message box, closes the message and the data file is skipped from loading. All the data files chosen are loaded in the order they are displayed in the data folder alphabetically. The data files must all match the first file loaded.

Removing a Profile from Data Display window

The user can only remove one profile at a time. The software always removes the data file that is in Focus, the data file displayed in the Filename text box.

With the mouse cursor select the **File** drop-down list at the top left corner of the **Data Display** window, and click.

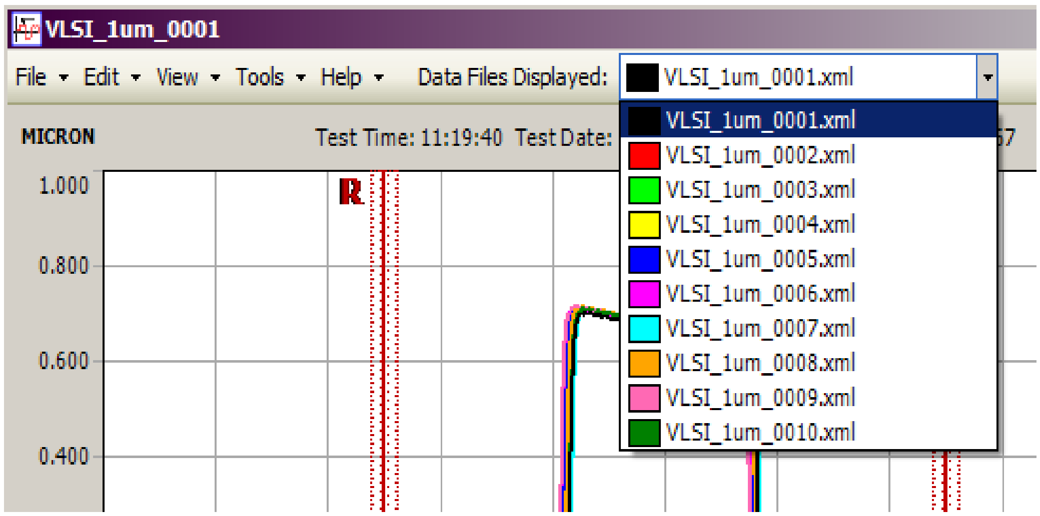
Click the **Remove Data File** option. The data file displayed in the Filename text box is removed from the **Data Display** window.

7.4.3.2 Using the Calculations for Multiple Profiles

Calculation results are only displayed for the profile in Focus. To view calculations on one of the profiles loaded into the Data Display window, that profile must be chosen as the Focus data.

The illustration in Figure 7-6 displays the file name drop-down list of the data files loaded in the data display window. The file name highlighted is the profile in focus.

Figure 7-6 List of Data Files loaded into Data Display Window



Changing the Focus of a Profile

With the mouse cursor, select the **File Name** drop-down list at the top left of the Data Display software screen. This opens the drop-down list showing all the data files loaded into the Data Display window.

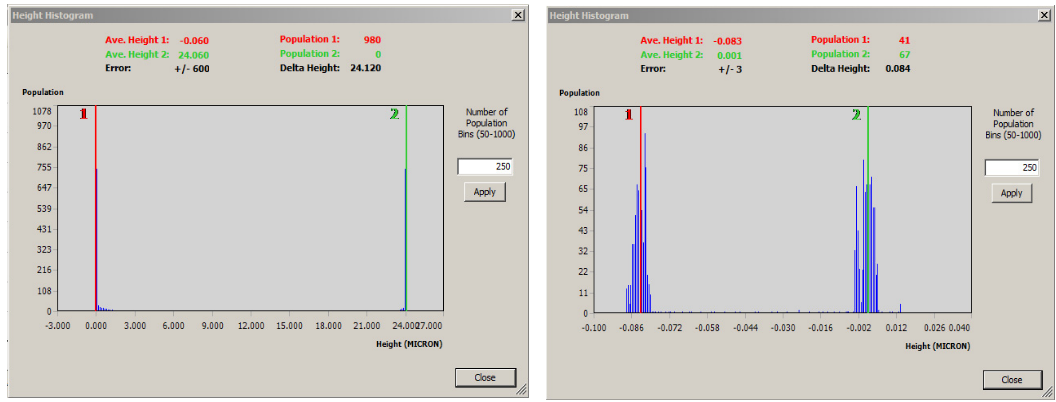
Click the data file, which you wish to have in Focus.

The chosen data file is displayed in the File Name text box with its corresponding color box displayed. Now this profile is in Focus.

7.5 Height Histogram

The Height Histogram sorts the Z data information into Bins (the user can control how many bins the data is sorted into), each bin contains a range of height data. Each data point in the profile is categorized into a bin. The Histogram plots the number of data points in each bin as a function of the Z range. The Histogram is a plot of the frequency of the Z data. The image on the screen is the only output of this feature.

Figure 7-7 Height Histogram in Data Display Active window



Left: histogram of an accurate step height with virtually no noise in the data
Right: histogram of a not well defined step height, the data peaks are spread showing the spread in the data

7.5.1 How to Use the Height Histogram

The Height Histogram can be used to make a statistically significant step height measurement. The height histogram is used to display the height distribution of the profile Z data. When operating on a step data set, for example, the histogram has a two peak distribution shown in Figure 7-7. One peak corresponds to the data points at one height (the substrate surface) and the second peak corresponds to the data points at the second height (the top of the step). The peak width is defined by the flatness of the feature. The more data points that have the same Z value, the taller the corresponding histogram peak and the narrower the peak. In the case of steps with significant surface roughness the peaks are broad. Viewing the data using the Histogram function allows the user to qualitatively determine the relative noise in the measurement and to quantitatively measure the step height using all of the data in the profile. Thus the user can make a statistically significant step height measurement. The following directions assume that you have already taken a scan and leveled the data.

From the Data Display window

1. Click **Height Histogram** located in the bottom right corner of the Display window.

   The Height Histogram window displays a default histogram with 250 bins.

2. In the **Number of Population Bins** field, choose the number of bins you wish to sort the data. Increasing or decreasing the number of bins changes the resolution and size of the histogram peaks respectively.
3. Click **Apply**. The window re-displays your data with the revised number of bins.
4. Click **Close** at the bottom of the window to close the **Height Histogram** window and return to the **Data Display** window.

8

Apex 2D/3D - Getting Started

Contents

8.1 Introduction

This chapter provides information about configuring Apex 2D/3D to work with the Alpha-Step system.

8.1.1 License Agreement

- The copyright laws and international treaties, as well as other intellectual property laws and treaties protect the software product.
- The software product is licensed as a single product. Its component parts cannot be separated for use on more than one computer.
- You cannot reverse engineer, decompile, or disassemble the software product.
- The source code was designed and developed by Digital Surf and is the property of Digital Surf, France.
- Apex 2-D and Apex 3-D are trademarks of KLA-Tencor Corporation.

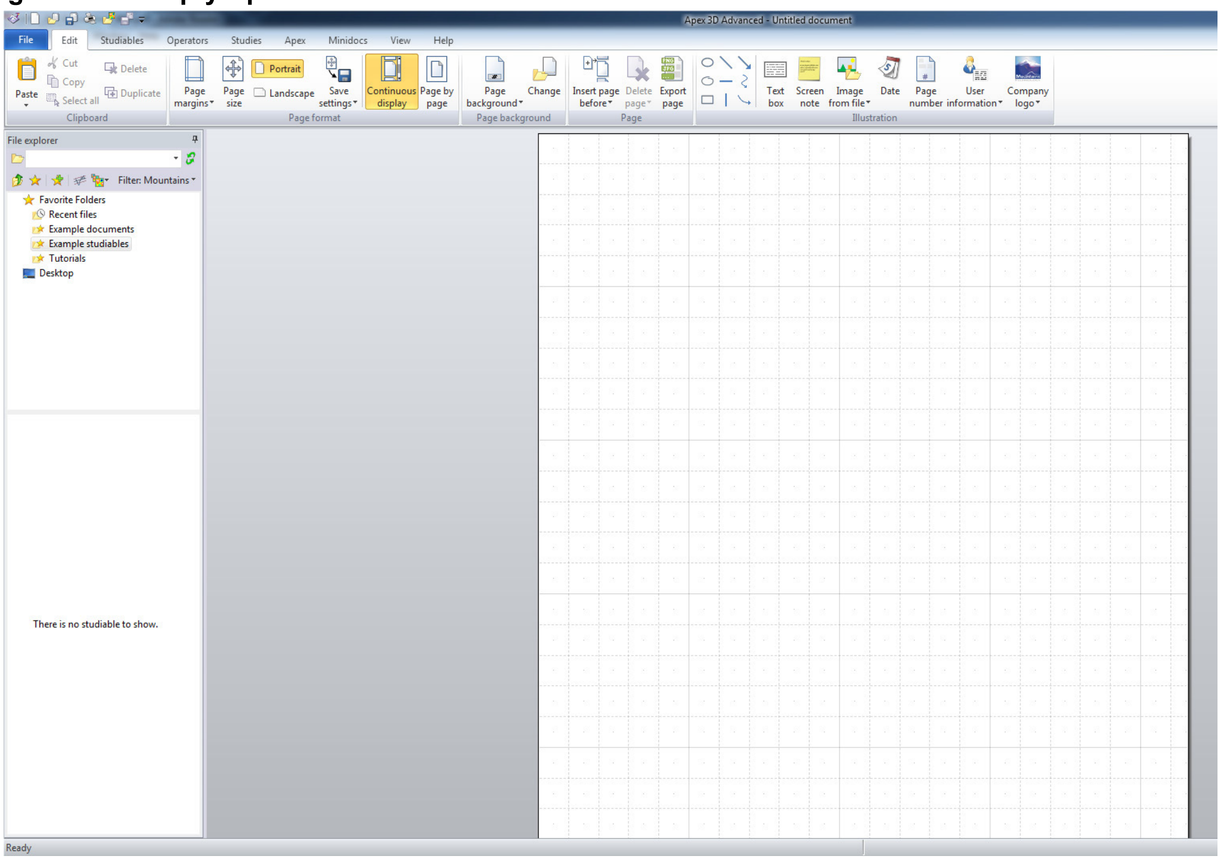
8.2 Overview of Apex 2D/3D

8.2.1 Starting the Software

To start the software, click the shortcut on the desktop, or click **Start > All Program Files > Apex 3D Advanced 7.3 > Apex 3D Advanced (64-bit version)**.

The program displays a document with the data set that is open in the Alpha-Step software. See Figure 8-1.

Figure 8-1 Empty Apex Document



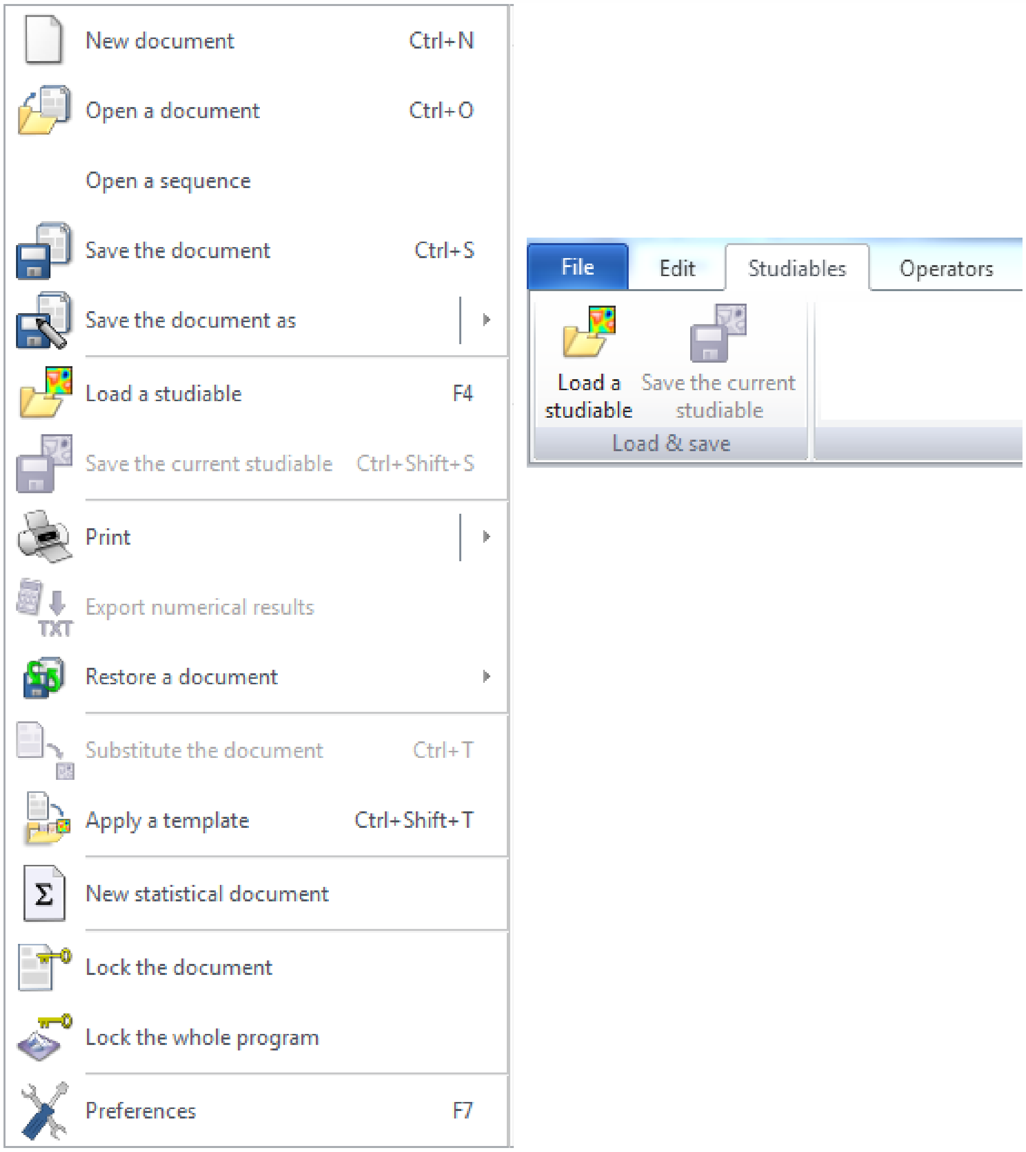
8.2.2 Loading a Studiable

Studiable is a word that refers to all data (2-D profile, 3D surface) that can be studied and that can be stored in a file. Apex can load files from a large number of measurement instruments.Refer to www.digitalsurf.fr/en/mntformats.htm for more information.

Click **Studiables > Load a Studiable**, or click the **Load a Studiable** icon in the **General** toolbar.

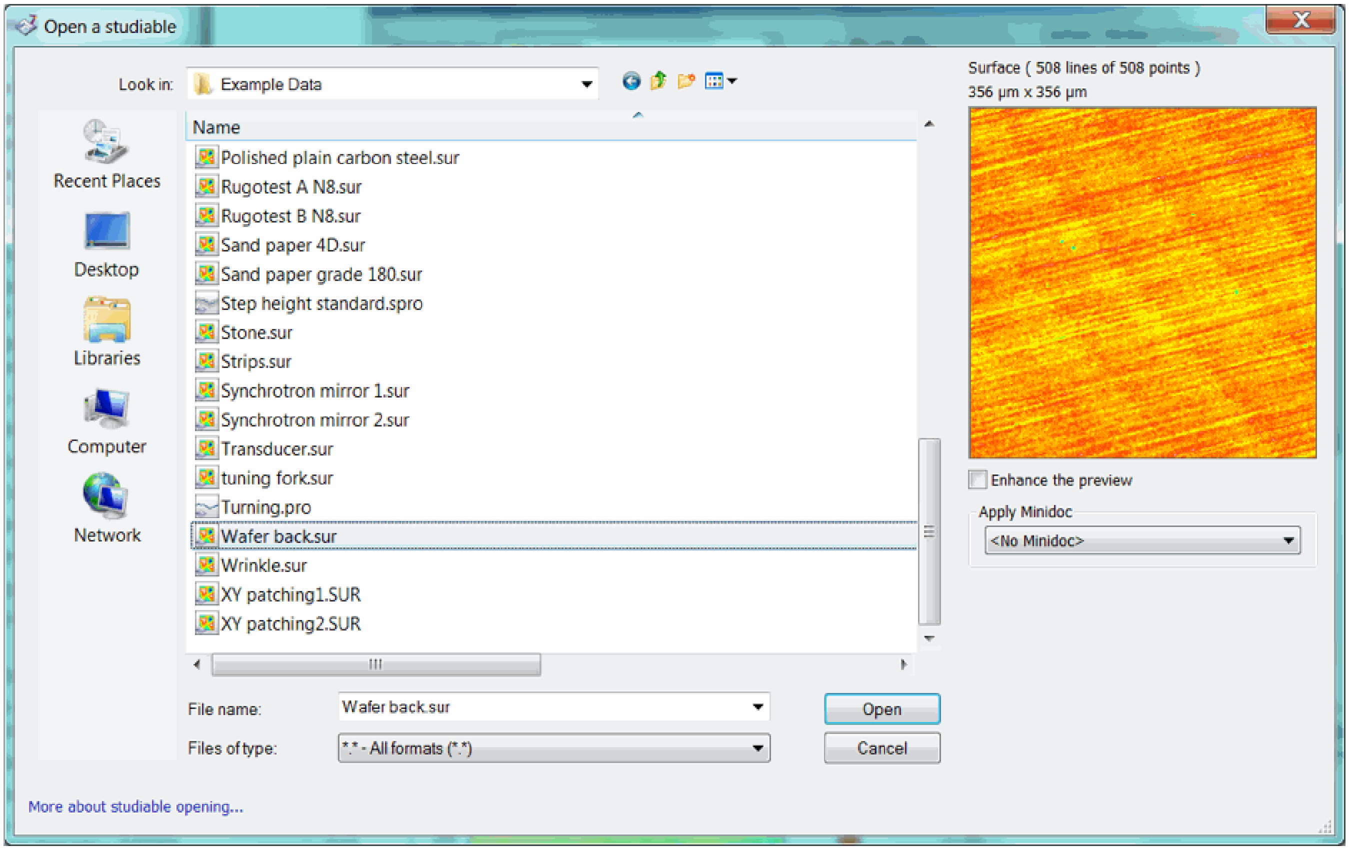
If 2-D data set is opened, the Profile Curve ribbon is active. If a 3D data set is opened the Pseudo-color view ribbon is available. See Figure 8-2.

Figure 8-2 General Toolbar



Navigate to the **Example Data** folder in the installation directory of the software, and click **Studiables**. Select one of the **.sur** or **.pro** files, for example double-click **Wafer back.sur**. See Figure 8-3.

Figure 8-3 Example Data Directory



The **.sur** file extensions are 3-dimensional surface files, whereas **.pro** file extension are 2-dimensional profile files.

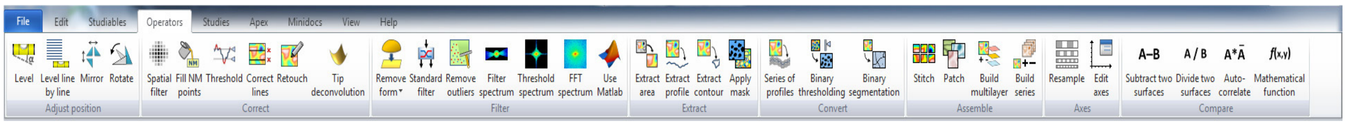
The studiable is displayed in reserve at the top left side of the document.

8.2.3 Applying an Operator or Carrying out a Study

An operator is a mathematical operation that is applied to a studiable and generates one or more new studiables.

To apply an operator, click any **Studiable** (the border is displayed as a dotted blue line), and then click an operator from the **Operators** menu (for example **Zoom**, **Level**, **Spatial Filtering**, **Remove form**). See Figure 8-4.

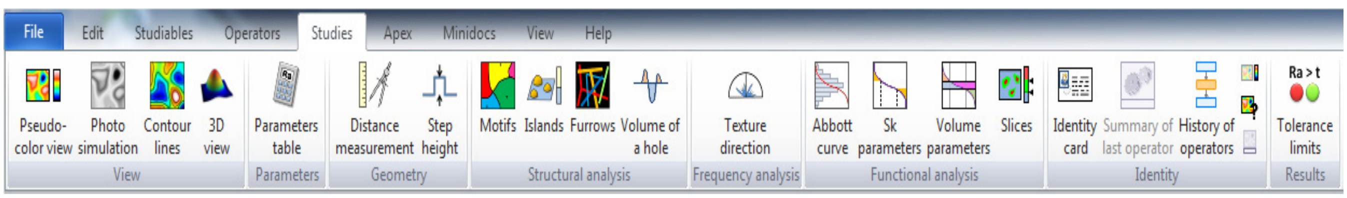
Figure 8-4 Applying an Operator



A study is a graphical representation of a **Studiable** (for example, 3D representation of a surface) or an analysis done on a **Studiable** (calculation of the Ra parameter).

To apply a study, select any studiable, then select a study from the **Studies** menu. See Figure 8-5.

Figure 8-5 Carrying out a Study



For complete information on how to use Apex, go to the **Help** menu and click **Reference Guide**.

Building an Analysis Document

Apex contains all the tools needed to build and lay out a complete Analysis Document in a straight forward way.

Figure 8-6 3D Representation of the Measured Motor Cylinder

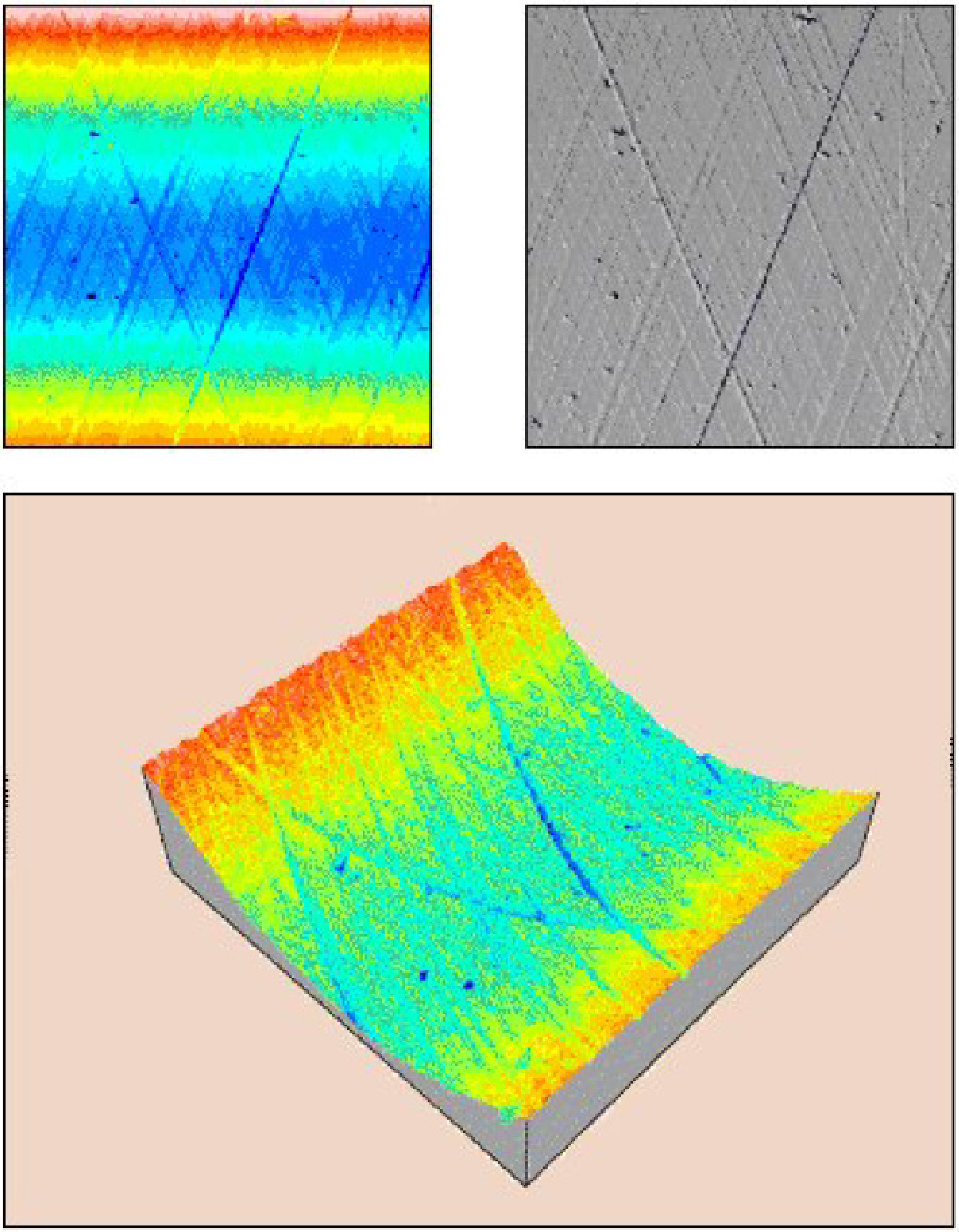
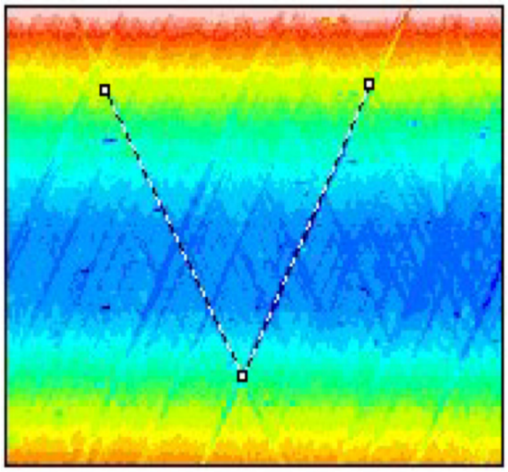
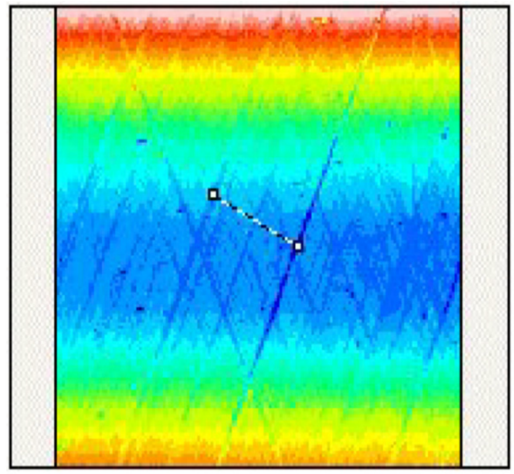


Figure 8-7 Measurement of the Angle and the Distance between Grooves

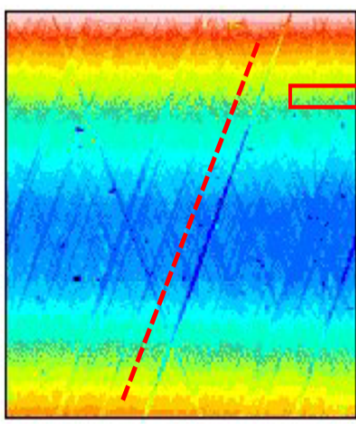


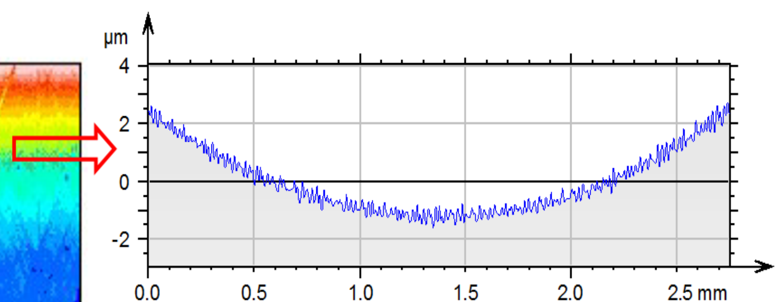
Angles	B	Unit
Angle	46.16	°



Distances	A	Unit
HDist	0.627	mm
ZDist	0.716	µm
ODist	0.627	mm

Figure 8-8 Extraction of an Oblique Profile





Parameters	Value	Unit
Length	2.75	mm
Pt	4.32	µm
Scale	7.00	µm

Figure 8-9 Removing the Circular Form

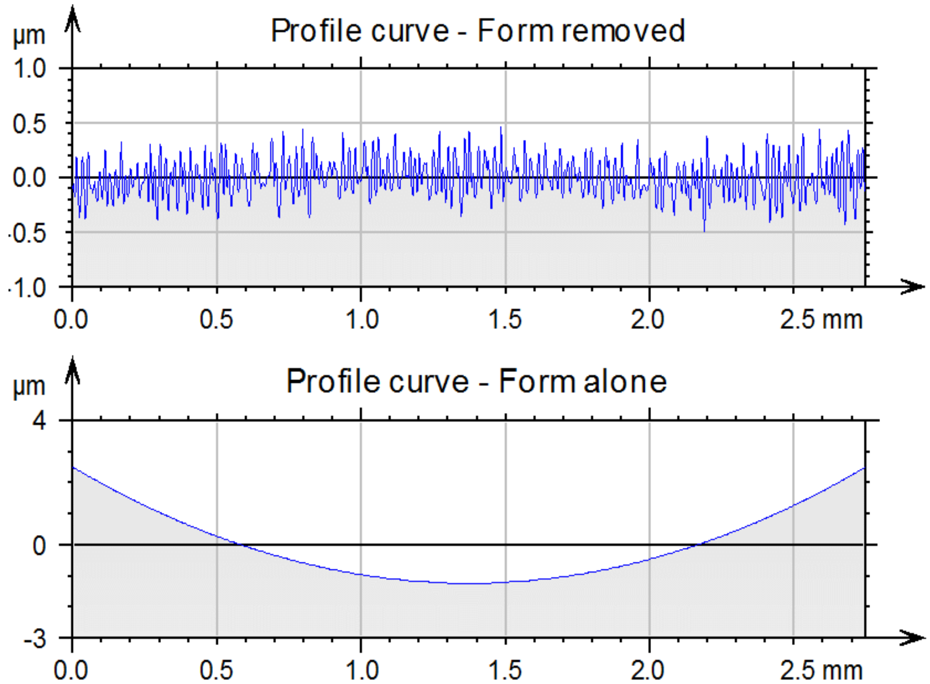
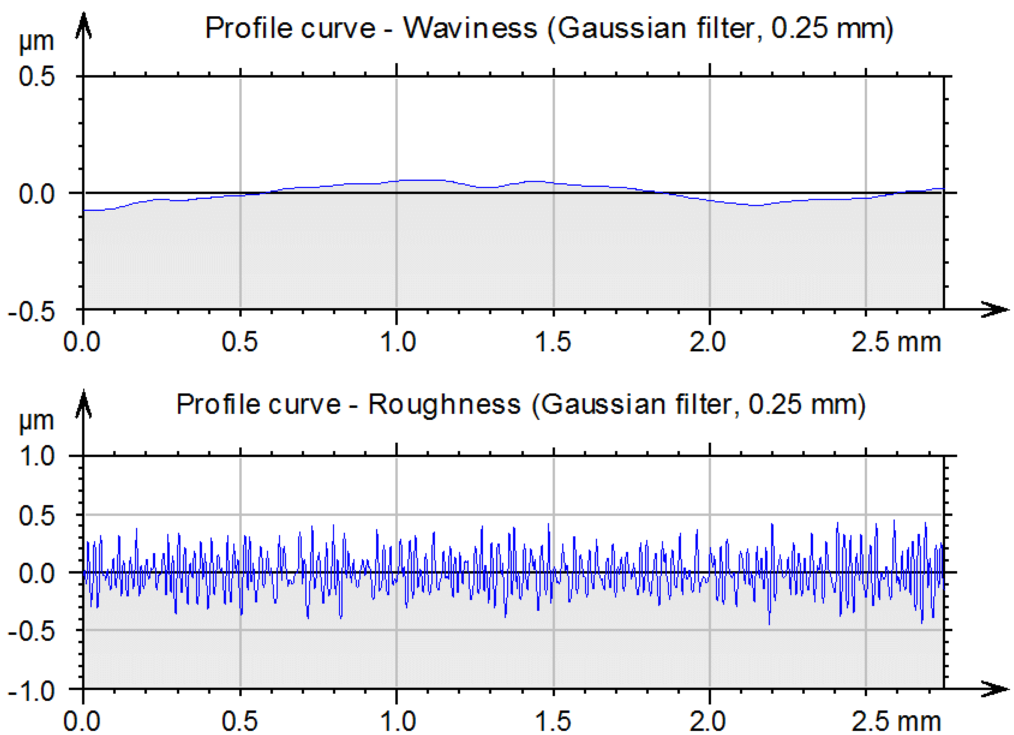


Figure 8-10 Separating Roughness and Waviness



The calculation is based on the Circular form removed profile curve.

A Gaussian filter of 0.25 mm is applied in the calculation.

Figure 8-11 Calculating Roughness Parameters

Symbol:	Ra	Symbol:	Rq
Standard:	ISO 4287	Standard:	ISO 4287
Family:	Amplitude parameters - Roughness profile	Family:	Amplitude parameters - Roughness profile
Full name:	Arithmetic mean deviation of the roughness profile.	Full name:	Root-mean-square (RMS) deviation of the roughness profile.
Context:	Gaussian filter, 0.25 mm	Context:	Gaussian filter, 0.25 mm

ISO 4287			
Amplitude parameters - Roughness profile			
Ra	0.129	µm	*Gaussian filter, 0.25 mm*
Rq	0.159	µm	*Gaussian filter, 0.25 mm*

Ra (GS 0.25 mm) = 0.129 µm, Rq (GS 0.25 mm) = 0.159 µm.

9

Thin Film Stress Module

Contents

9.1 Introduction

This chapter describes the Thin Film Stress software and gives a tutorial on how to use the module. Also, described in this chapter is the optional Wafer Stress Chuck. The Stress Module has an additional capability that allows the user to subtract profiles and save the new profile. This Difference measurement can be used for comparing profiles or subtracting a background noise floor. A description and tutorial is included in this chapter.

9.1.1 Overview

It is important to monitor thin film stress as thin film stress data can be used to reduce process variations. Stress is generated in the thin film and substrate during thin film deposition. The deformation of the thin film can be monitored by the bending, compressing, or expanding of the substrate (as evident by the curvature of the substrate and film).

With the Thin Film Stress Option, the **Alpha-Step Development Series** profiler can be useful to determine the stress levels in a deposited film by measuring the deflection or curvature that the stress induces in the substrate. The software determines the curvature of the sample by calculating the least square fit of the trace data to a circle. The equation for stress is as follows:

ó = [1/6R] [E/(1-õ)] [ts^2/tf]

where:

E/(1-õ) = substrate elastic constant

E = Young's Modulus õ = Poisson Ratio

ts = substrate thickness; tf = film thickness

R = radius of curvature

The software calculates the radius of curvature by using a least squares fit method. This result can be verified by using the following equation for radius of curvature R:

$R = L^2/8B$ if L>>B Where:

B = bow (maximum between the trace and its chord)

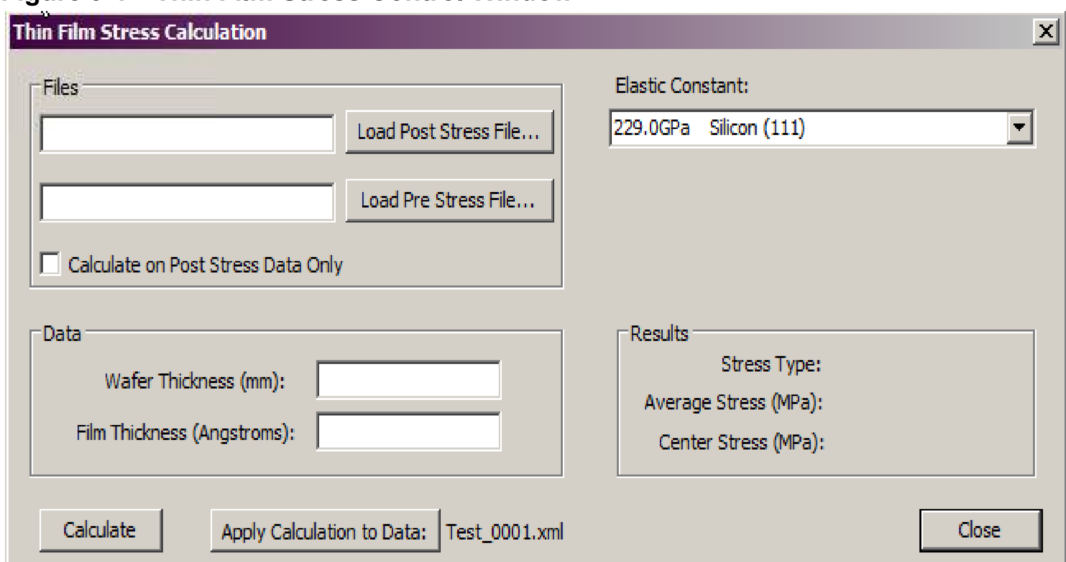
L = chord length (scan length)

The software uses manually entered values for:

ts (substrate thickness)

9.2 Thin Film Stress Window

Figure 9-1 Thin Film Stress Control Window



The **Alpha-Step Development Series** profiler software calculates:

The average stress derived from the least square fit of the entire profile

The center stress computed at the center third of the profile

Thin Film Stress – The Thin Film Stress option window might be opened from the **Tools** drop-down list on the Main software screen.

Load Post Stress File – This button opens a Load Data File window. The user can Browse to the data file containing the measurement data after processing.

Load Pre Stress File – This button opens a Load Data File window. The user can Browse to the data file containing the measurement data before processing.

Elastic Constant – This field allows the user to choose from a drop-down list of common substrate elastic coefficients or to directly enter a value into the text field. All the values are assumed to be in units of GPa.

Wafer Thickness (mm) – This field requires the user to enter the known sample thickness in units of millimeters (mm).

Film Thickness (Angstroms) - This field requires the user to enter the known film thickness in units of Angstroms.

Results – After the user loads the data sets into the software and enters the proper sample information and presses the **Calculate** button, the stress results are displayed in the **Results** field.

Stress Type – The software uses the Stoke Model for calculating the stress based on the curvature of the profile. The results are categorized as either **Compressive or Tension Stress** types.

Average Stress (MPa) – This field displays the calculated average stress of the film on the substrate for the length of the profile data.

Center Stress (MPa) - This field displays the calculated stress of the film on the substrate at the center of the profile data.

9.3 Using the Thin Film Stress Option

The software allows the user to compare pre- and post-processing profiles to determine the curvature caused solely by the process induced stress. If no preprocessing scans are available, the software allows the operator to make a wafer stress calculation on post-processing scans and assume the sample was perfectly flat prior to the stress inducing process. The post-process stress measurement is inherently less accurate than the difference measurement method.

It is important that the sample be measured in the same location and with the same scan sequence to produce accurate and repeatable stress measurements using the difference measurement method. To facilitate sample placement, a chuck adapter should be used for the most accurate and repeatable results. This adapter keys off of the standard chuck (supplied with the system) and provides sufficient positional accuracy.

NOTE

It is important that the scans taken for the Thin Film Stress Option be measured using identical setup parameters or software error might occur.

9.3.1 Saving Data

To re-compute and display a difference measurement, both pre- and post-stress profiles must be saved. Saving the profiles allows the user to recalculate the stress value using different parameters.

The pre- and post-stress profiles are saved using the same instructions as described in Chapter 5, “Basic Operation,” on page 55.

9.3.2 Taking a Pre-stress Scan

Pre-stress data displays a profile of the sample before the sample is stressed by processing. The data establishes a baseline for later comparisons.

9.3.3 Saving and Loading a Scan Recipe/Sequence Recipe

To save a scan recipe/sequence recipe,

1. From the **Main** window, select the required option from **File** drop-down list at the top left corner of the window.
2. Click **Save Scan Recipe/Save Sequence Recipe**.

A dialog box is displayed showing the save-in folder.

3. Choose a folder and type the name of the scan recipe/sequence recipe, and then click **Save**.

The current parameter settings are now saved in the selected folder as a scan recipe/sequence recipe.

To load a scan recipe/sequence recipe,

1. From the **Main** window, select the required option from **File** drop-down list at the top left corner of the window.
2. Click **Load Scan Recipe/Load Sequence Recipe**.

A dialog box is displayed showing the folder of all the previously saved recipes.

3. Choose the target scan recipe/sequence recipe, and then click Open.

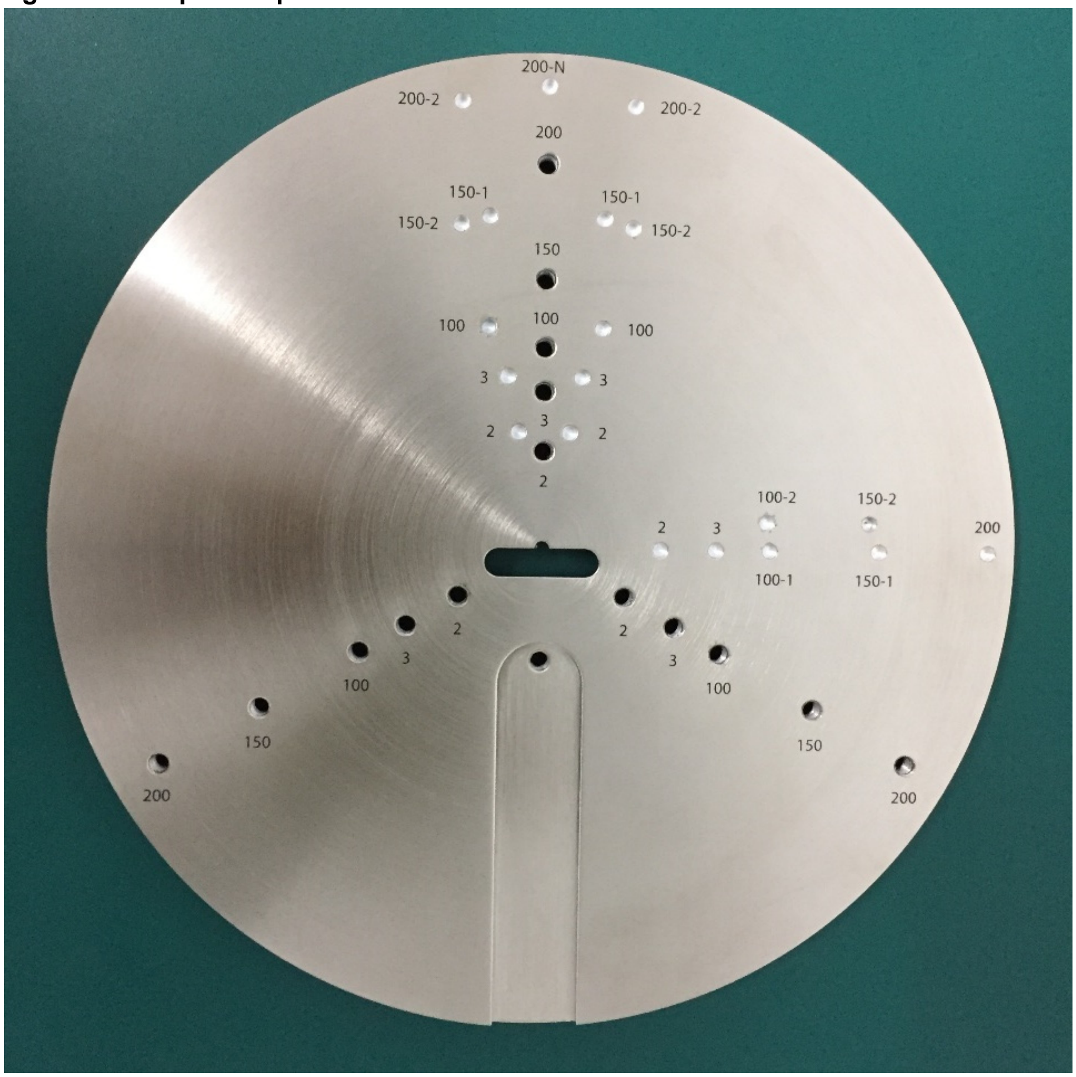
The parameter settings in the selected scan recipe/sequence recipe are now loaded to the software.

9.3.4 Loading and Positioning the Sample

Alpha-Step D-600 Wafer Stress Chuck

The Alpha-Step D-600 wafer stress chuck (see Figure 9-2) is designed to support the wafer during wafer stress measurements. To add the wafer chuck to the standard chuck, use the instructions provided with the wafer stress chuck, Installing a Precision Locator.

Figure 9-2 Alpha-Step D-600 Wafer Stress Chuck

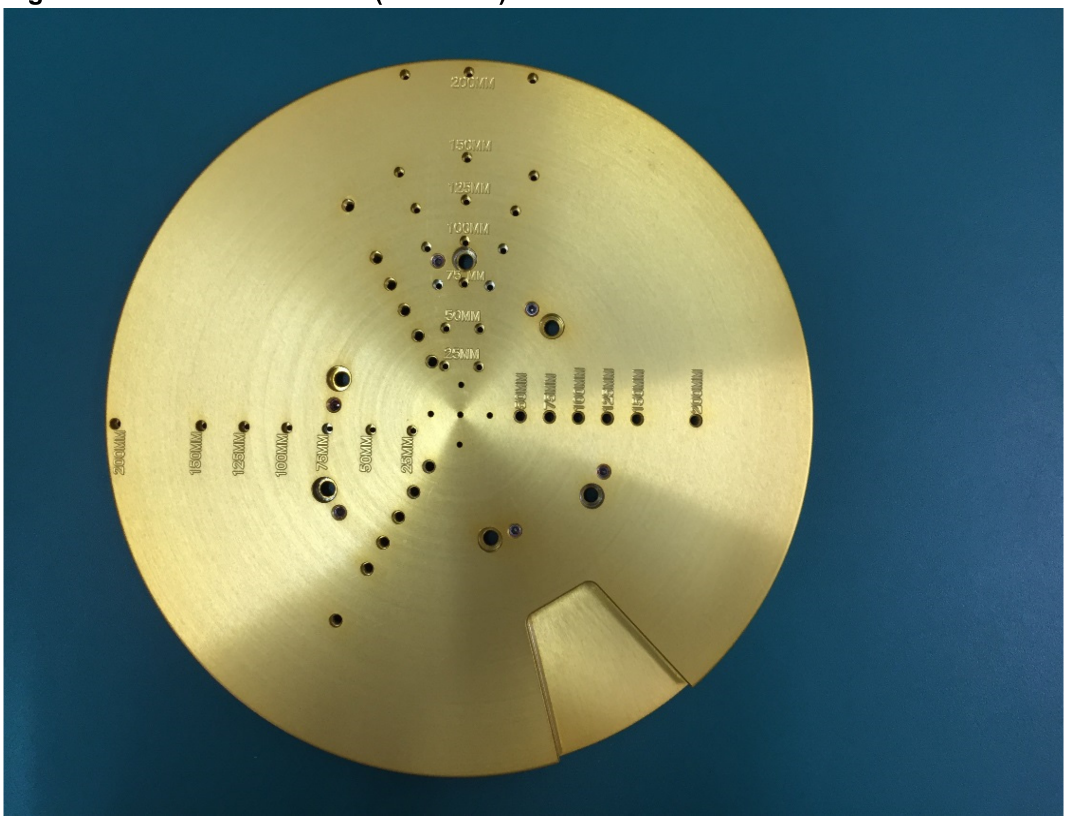


Three wafer support pins can be located for the wafers of nominal sizes 2 to 8 inches.

Universal Chuck

Universal chuck equipped with a stress precision locator can also be used for the film stress measurement on D-600. And it is available to enable exact positioning of a sample relative to a fixed reference, flat or notch. The chuck allows various positions for the locating pins and standoffs to accommodate wafers from 50 mm to 200 mm (2 in. to 8 in.). See Figure 9-3.

Figure 9-3 Universal Chuck (for D-600)



Alpha-Step D-500 Wafer Stress Chuck

The Alpha-Step D-500 wafer stress chuck (see Figure 9-4) is designed to support the wafer during wafer stress measurements on D-500. To add the wafer chuck to the standard chuck, use the instructions provided with the wafer stress chuck, Installing a Precision Locator.

Figure 9-4 Alpha-Step D-500 Wafer Stress Chuck

Three wafer support pins can be located for the wafers of nominal sizes 2 to 6 inches.

Placement of the Wafer

The procedure assumes that the stress locators are in place on the chuck. The wafer rests on the three stress locators, so the chuck does not change the shape or stress of the wafer.

For Alpha-Step Wafer Stress Chuck:

1. Place the wafer on the three pin locators. Rotate the wafer so that the flat/notch is facing the front of the stage towards the operator.
2. Center the wafer on the three pin locators. Use your finger tips to align the wafers outer edge on the pins.

For Universal Chuck:

1. Mount proper locating pins on the chuck according to the wafer size and reference type (notch/flat).
2. Place the wafer on the three stress locators, use locating pins to precisely locate the wafer: the flat/notch is firmly against the locating pin(s), and the wafer left side is against the other locating pin.

This ensures that the wafer is loaded in the correct orientation and location for the pre and post measurements.

NOTE

When manually loading the sample, make note of the position of the sample on the sample chuck. To compare pre- and post-stress measurements, you must duplicate the scan position for both measurements as close as possible to reduce user-induced variation to the calculations. Also, ensure that the scan parameters are identical for each of the scans or this might cause an error message to displayed when making the Wafer Stress Calculation.

For more information on loading and positioning the sample, refer to Chapter 5, “Loading the Sample,” on page 57 and Chapter 5, “Control Panel Tab,” on page 62.

Load a sample for which you already have a Scan Recipe/Sequence Recipe saved. Otherwise, refer Chapter 4, “Description of Features,” on page 23 for instructions on changing the Scan parameters.

Profiling the Sample

Thin Film Stress measurement always requires a relatively long scan. For D-600, the maximum length of a single scan is 55 mm, and an auto-stitching scan can extend the scan length to 200 mm. To take an auto-stitching scan as a pre-stress scan:

1. Create and save a scan recipe with proper scan parameter settings. For the details about setting the scan parameters, refer to Chapter 4, “Scan Parameter Tab,” on page 42 for saving a scan recipe, refer to Chapter 9, “Saving and Loading a Scan Recipe/Sequence Recipe,” on page 148.
2. In **Sequence Control** panel, click **Scan** to load the previously saved scan recipe.
3. Move the sample to the starting point, and add the coordinates as the first measurement site.
4. Select **Matrix Mode**, select the **Stitch** check the box, set Rows (Y) and Pitch numbers based on the scan length.
5. Click **Populate** and the site coordinates is added to the site list automatically.
6. Click **Save As** to save the current sequence recipe. For details about saving a sequence recipe, refer to Chapter 9, “Saving and Loading a Scan Recipe/Sequence Recipe,” on page 148.
7. Click **Start** and a **Sequence Scan File Name** dialogue box is displayed.
8. Type the **Root File Name**, select the **Data Path**, and then click **OK**. It starts to scan.

The **Main** window is displayed during the scan. After the scan is complete, the **Data Display** window is displayed with the stitched profile and individual profiles, and all the data files are saved in the target folder.

9.4 Taking a Difference Measurement

A difference measurement compares the stress data in the current profile with pre-stress data from an earlier profile. An example of this would be measuring a deposited film step on a non-uniform surface and then removing the step feature and measuring the sample in the same location, then subtracting the substrate profile from the step profile to get only the step shape for a height measurement. The procedure requires a pre-process (or substrate) data file and a post-process (or feature of interest) data file. The two saved files are then be subtracted to get the profile of interest.

NOTE

If a pre-stress profile has not been saved before computing a difference measurement, the difference measurement can be computed assuming a totally flat pre-stress sample profile.

9.4.1 Selecting a Sequence Recipe

You should use the same sequence recipe for the pre-stress and post-stress profiles. For details about loading a sequence recipe, refer to Chapter 9, “Saving and Loading a Scan Recipe/Sequence Recipe,” on page 148.

9.4.2 Loading and Positioning the Sample

Before loading the sample, check if following requirements are met:

- The sample has been processed.
- It was scanned before the processing.
- The pre-stress profile has been saved in the data folder.

To position the sample for a difference measurement:

NOTE

Position the sample exactly as it was positioned for the pre-stress scan.

1. If you are using the Precision Wafer Chuck, use the precision locator with the three support points. Ensure that you position that sample the way it was positioned for the pre-stress scan paying particular attention to the rotation of the sample on the sample holder.

   The precision locator has fittings that locate the wafers of various sizes in X, Y. It supports the wafers in a way that minimizes gravitational distortions, but also ensures that the residual gravitational distortion is the same for both the pre- and post-stress scans.

2. The user can program the instrument so that the load position moves the stage to exactly the right scan position.

9.5 Taking a Single Post Stress Management

A single, post-stress measurement measures the current curvature of the sample. In such a calculation, the software assumes that the sample is flat before being processed and stressed.

To take a single, post-stress measurement:

3. Load the sample.
4. Profile the sample. Refer to Profiling the Sample on page 153 for details.
5. Go to **Thin Film Stress Calculation** window.
6. Enable the Calculate on Post stress data only box (this deactivates the post-stress file field).
7. Click **Load Post Stress File** and choose the post-stress file name applicable to the calculation.
8. Type the stress parameters in the appropriate fields of the **Thin Film Stress Calculation** window.
9. Click **Calculate**.

The stress calculations are displayed. You can print the calculation results from the **Results** dialog box.

9.6 Recalculating Stress Measurements

The user can recalculate stress measurements provided the pre-stress profile and post-stress profile(s) have been saved. For example, you can do this to correct a mistake for film thickness that was entered when a previous wafer stress calculation was made.

To recalculate a measurement:

1. Open the Thin Film Stress Calculation window.
2. In the **File** field, load the pre-stress and post-stress profiles that you wish to use for the new wafer stress calculation or difference profile.
3. Enter the appropriate stress parameters and elastic constant (refer to "Thin Film Stress Window" on page 145 for details).
4. Select **Apply Calculation to Data**. The summary calculations are displayed in the dialog box and the difference is subtracted from the last open data set.
5. Close the **Thin Film Stress Calculation** window.
6. View the **Data Display** window to see the difference profile.
7. Save the new difference profile.

9.7 Use a Difference Measurement to Subtract from a Scan Profile

The Thin Film Stress software feature provides the user with a means of removing systematic noise inherent to the profiler during sensitive measurements of very small features.

The procedure requires the use of an optical flat or similar sample that can be used as the background scan data which is subtracted from the sample scan data. The background scan is contains any systematic noise without contributing any data due to measurable features which when subtracted from the sample of interest is affects the final profile data.

9.7.1 Taking a Background Scan

1. Load the optical flat or comparable sample for which you already have a scan recipe or sequence recipe (otherwise refer to Chapter 4, "Scan Parameter Tab," on page 42 for instructions).
2. Press **Scan**. The Main software screen is displayed during the scan. After the scan is complete, the Data Display window is displayed with the profile.
3. Right-click the **Data Display** window and select **Save As**.
4. The Data folder dialog box is displayed. Type a file name that can be easy to associate with the background systematic measurement.
5. Press **ENTER** or click **Save**.

To remove the systematic noise from a scan and display the difference profile and data:

1. With the sample loaded and ready, press the **Scan** button on the Main software screen.
2. The Data Display window opens with the profile. Save the data.
3. Open the Wafer Stress Calculation window.
4. In the Files box are two fields, the pre-stress file field and the post-stress file field.
   - Click **Load Pre-stress File**. A dialog box opens listing the saved profiles in the Data folder. Choose the systematic background profile to be used for the subtraction.

- Click the **Load Post-stress File**. A dialog box opens listing the saved profiles in the Data folder. Choose the sample of interest profile from which you wish the systematic noise to be subtracted.

5. Enter the stress parameters as described in, “Thin Film Stress Window” on page 145.
6. Select the **Apply Calculation to Data** button. Ignore the calculated stress values as they are erroneous.
7. Close the **Thin Film Stress Calculation** window.
8. Open the **Data Display** window. The profile data shown is the difference of the sample of interest and the systematic background noise.
9. From the **Data Display** window, right-click to open the drop-down list.
10. Select **Save As**.
11. In the **Save As** window, type a name for the profile. Press **ENTER** or click **Save** to save the data and close the window.

10

System Maintenance

Contents

10.1 Introduction

This chapter gives information that is useful in maintaining and troubleshooting the **Alpha-Step Development Series** profiler. Included in this chapter is a description of the KLA-Tencor Service Policy. A useful section for users with multiple styli or in the case one is replaced; there is a procedure for how to exchange a stylus. The **Alpha-Step Development Series** profiler Application has an electronic Help resource. We give a basic description of how to use this help tool. The Chapter ends with a list of common software Error messages and a description of the most common causes for the message and then a basic response to the message.

10.2 Linear Calibration Procedure

The linear calibration procedure is an automated test and self-correction routine used to reduce measurement error across the entire sensing area of a given range. This is necessary in order to compensate for the natural non-linear response of the electro-optical system. Without correction the measurement accuracy of the tool is under-optimized.

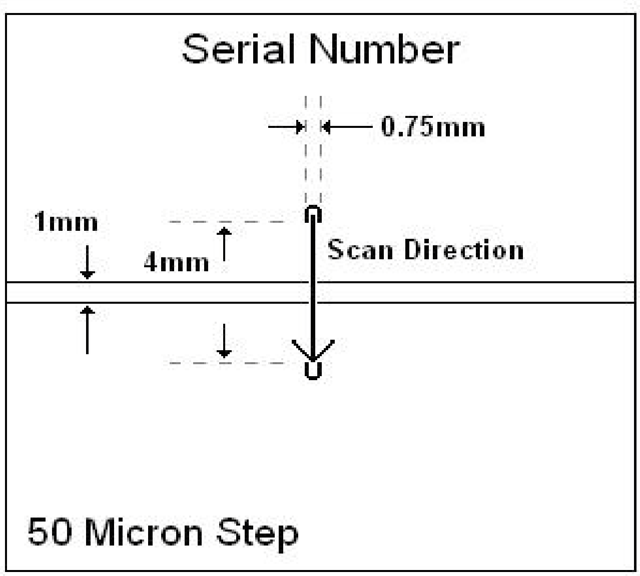
During the procedure the user is given the option to calibrate any individual range, all short ranges (2.5 µm, 10 µm and 100 µm), or all long ranges (550 µm and 1200 µm). Short Range and Long Range calibrations are done separately, as 2 different step-height standards are used in the procedures. A 1 µm (10,000 Å) step-height standard must be used when calibrating any Short Range, and a 50 µm standard must be used when calibrating any Long Range. Detailed in the following is a walk-through of the linear calibration procedure. It is critical to the performance of the instrument that these steps are followed when performing the linear calibration of any and all measurement ranges.

If all measurement ranges are to be calibrated always calibrate the Long ranges first.

10.2.1 Long Range Calibration

1. Calibration Sample: Place your 50 µm step-height standard on the scan-stage and align the step so that you can measure the calibrated region within the U shaped designators, as shown in Figure 10-1 (The arrow in Figure 10-1 shows where both linear and Z-height calibrations should take place).

Figure 10-1 50 µm Step Measurement Feature



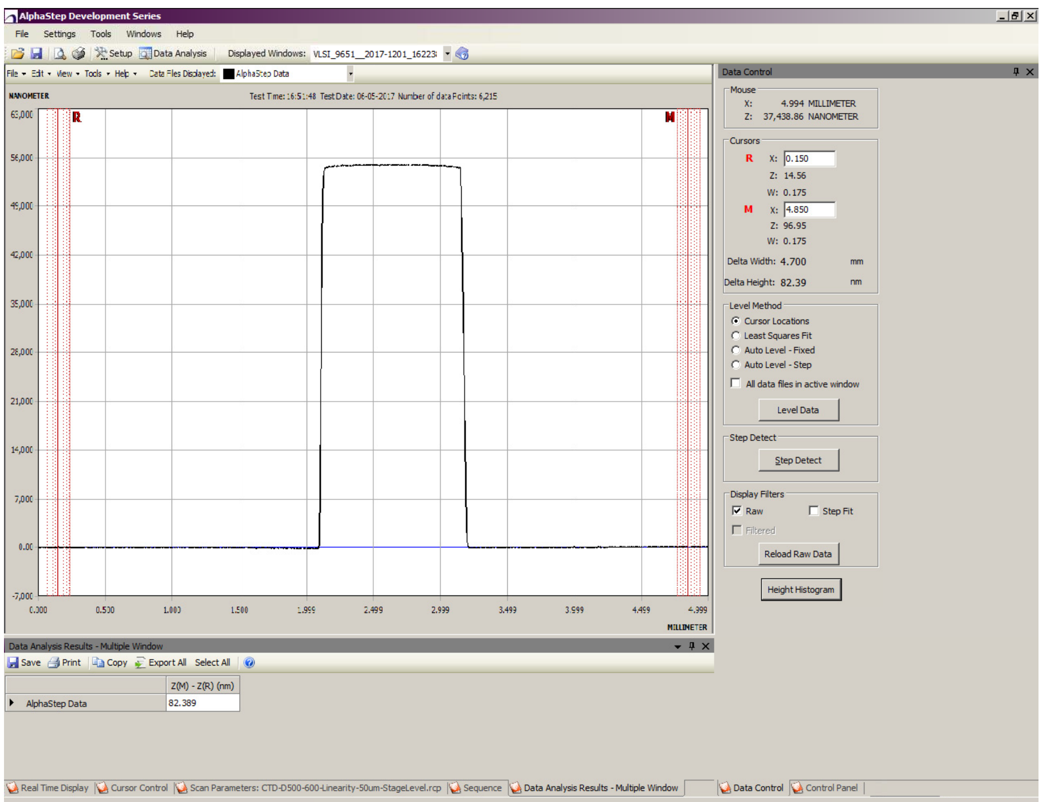
2. Level Scan Stage: In order to ensure an accurate calibration the scan stage must be precisely leveled. Navigate to the toolbar and click File > Load Scan Recipe and open the Scan Recipe labeled **CTD-D500-600-Linearity-50 µm-StageLevel.rcp**.

3. Click **Data Analysis** to view the **Z(M) - Z(R)** value of the cursor positions within the scan data, or simply observe the **Delta Height** value in the Data Control panel at the right of the screen. This value must be less than 2,000 Å before proceeding to the next step in the calibration procedure. Adjust the scan stage tilt wheel and continue to test scans until this requirement is achieved.

   Refer to the Manual Stage Leveling section of the user manual for a description of the leveling process.

Figure 10-2 shows scan data resulting after proper stage leveling:

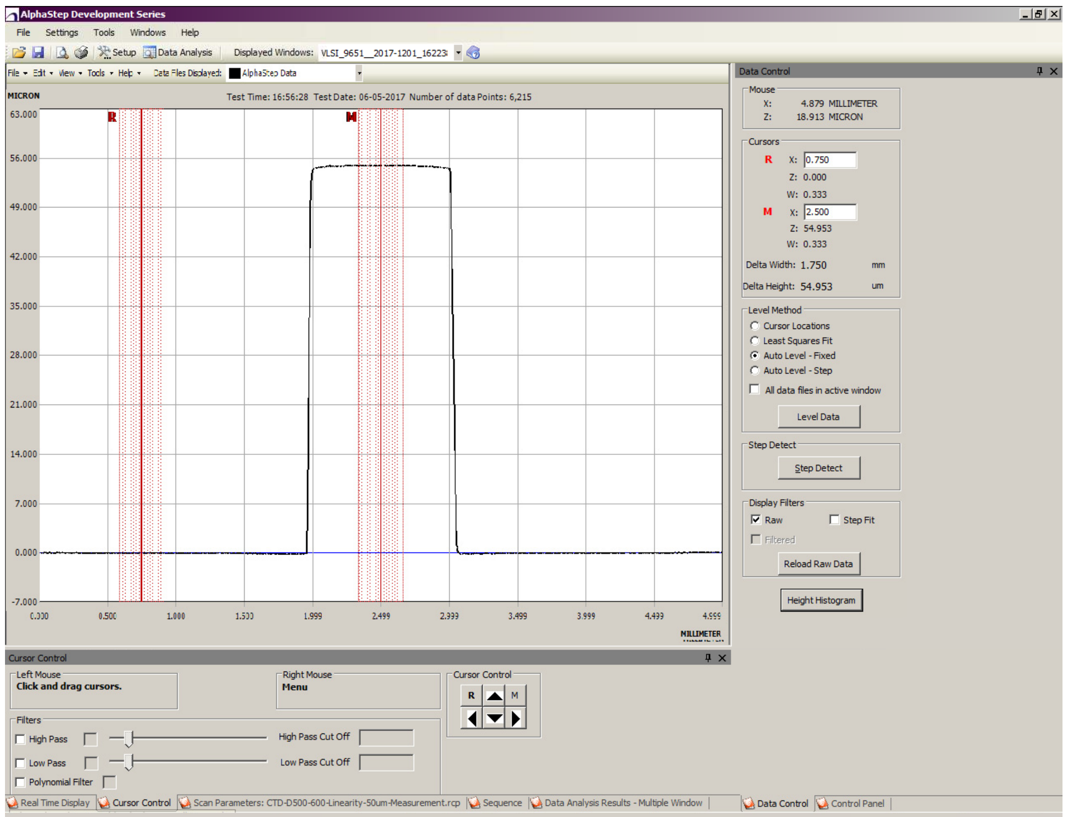
Figure 10-2 Measurement Feature (Precise Stage Leveling)



4. Align the Step: After the sample is level navigate to the toolbar and click **File > Load Scan Recipe** and open the file labeled **CTD-D500-600-Linearity-50 µm-Measurement.rcp**. This file sets the auto functions to level and measure the feature with respect to particular locations. In order to ensure accurate measurements the Y-position of the stage must be set precisely so that the center of the step-height feature aligns with the center of the scan length.

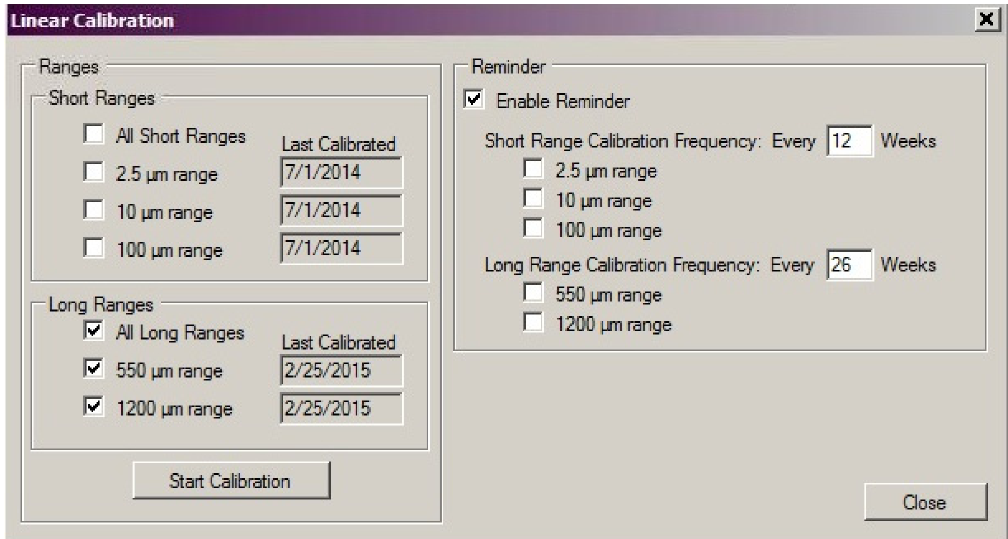
5. Adjust the position of the step and perform subsequent test scans until the resulting scan data is displayed as shown in Figure 10-3:

Figure 10-3 Measurement Feature Centered in Middle of Scan Length



6. Begin Long Range Linearization: Type the L key, or select **Tools > Linear Calibration** from the tool bar, and the Linear Calibration panel is displayed as shown in Figure 10-4.

Figure 10-4 Linear Calibration Panel



The upper and lower sections on the left-side of the panel provide the calibration options and the previous dates of calibration for each range (this is stated in standard US date notation: Day/Month/Year).

Because the 50 µm step-height is only used to calibrate the Long Ranges, only the section for the Long Ranges is of interest. Choose from among the Long Range options - individual calibrations of the 550 µm and 1200 µm, or All Long Ranges. The comprehensive All Long Ranges option is always recommended and takes roughly 25 minutes to complete. After the option is chosen,. click **Start Calibration** at the bottom of the panel.

Before the procedure begins, pop-up messages are displayed to ensure that the user has properly set-up the scans according to steps 2 and 3 of this procedure. The first asks if the stage has been leveled (as shown in Figure 10-5), while the second asks if the proper step-height standard has been chosen and aligned correctly (as shown in Figure 10-6).

Figure 10-5 Leveling Scan Stage

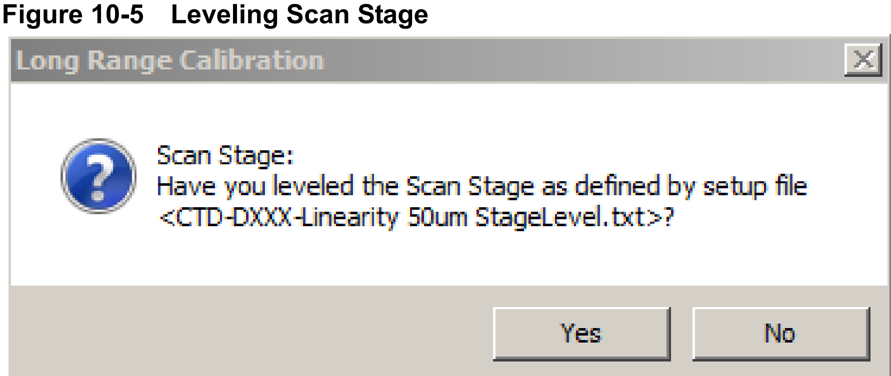
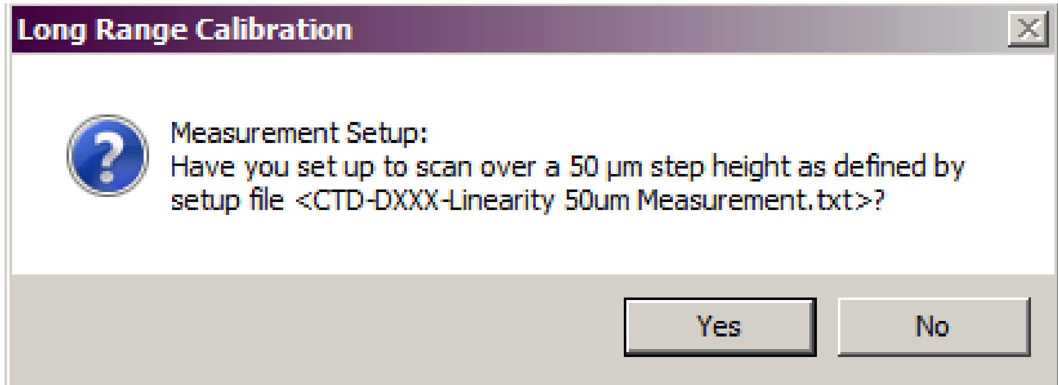


Figure 10-6 Scan Over 50 µm Step Height



The automated routine begins if Yes is selected for both of the questions. Leave the instrument undisturbed during the routine.

7. End Long Range Linearization:

   After the calibration successfully completes the dates in the panel is update. Close the Linear Calibration panel.

8. Z-Height Calibration:

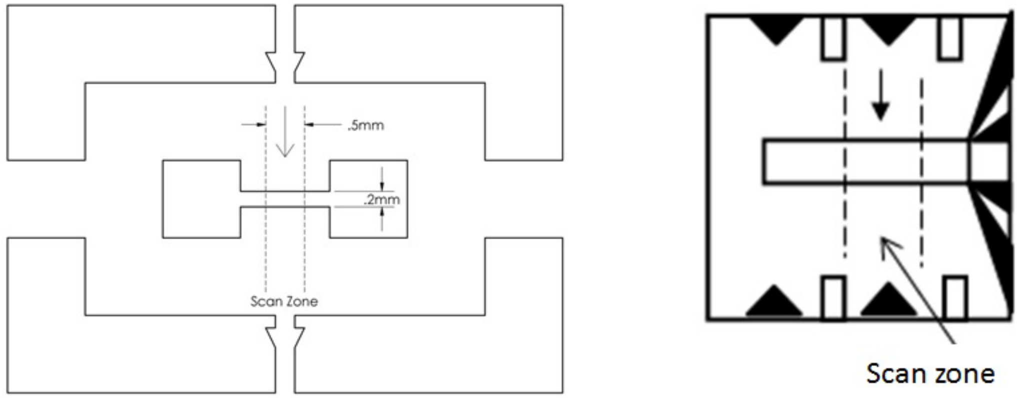
   Perform a Z-height calibration (refer to Calibrating the Measurement Head) on any range that was calibrated for linearity in the above sections.

   Remove the 50 µm step-height standard from the scan stage.

10.2.2 Short Range Calibration

1. Calibration Sample: There are two types of 1 µm step height standards as in Figure 10-7. One of them is shipped with the tool. Place your 1 µm step-height standard on the scan-stage and align the step so that you can measure the calibrated region shown between the dotted lines as shown in Figure 10-7 (Between the dotted line are where both linear and Z-height calibrations should take place; for both types of step stands, the features that can be used are at the center of the standard.).

Figure 10-7 1 µm Step Measurement Feature

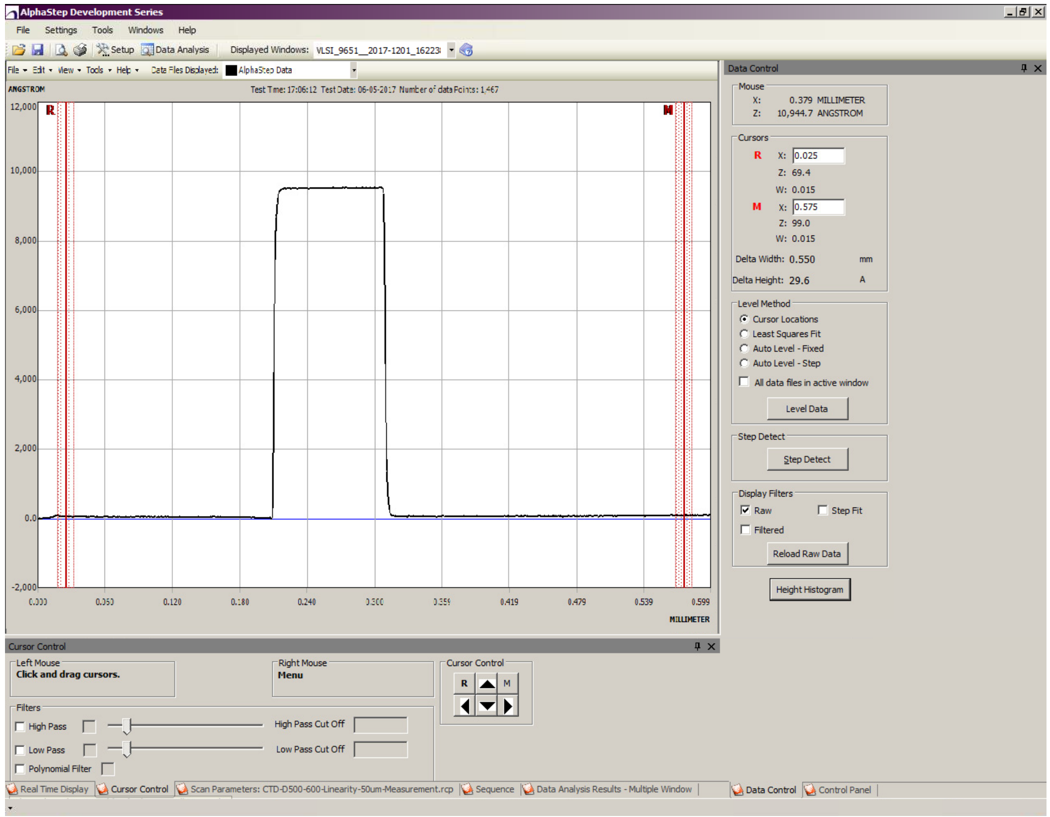


2. Level Scan Stage: In order to ensure an accurate linear calibration the scan stage must be precisely leveled. It is important to complete this step, even if the stage was previously leveled for Long Range calibration, because the two calibration samples (1 µm and 50 µm steps) might inherently have different degrees of tilt.

   Navigate to the toolbar and click File > Load Scan Recipe and open the file labeled **CTD-D500-600-Linearity-1 µm-StageLevel.rcp**. Perform a test scan.

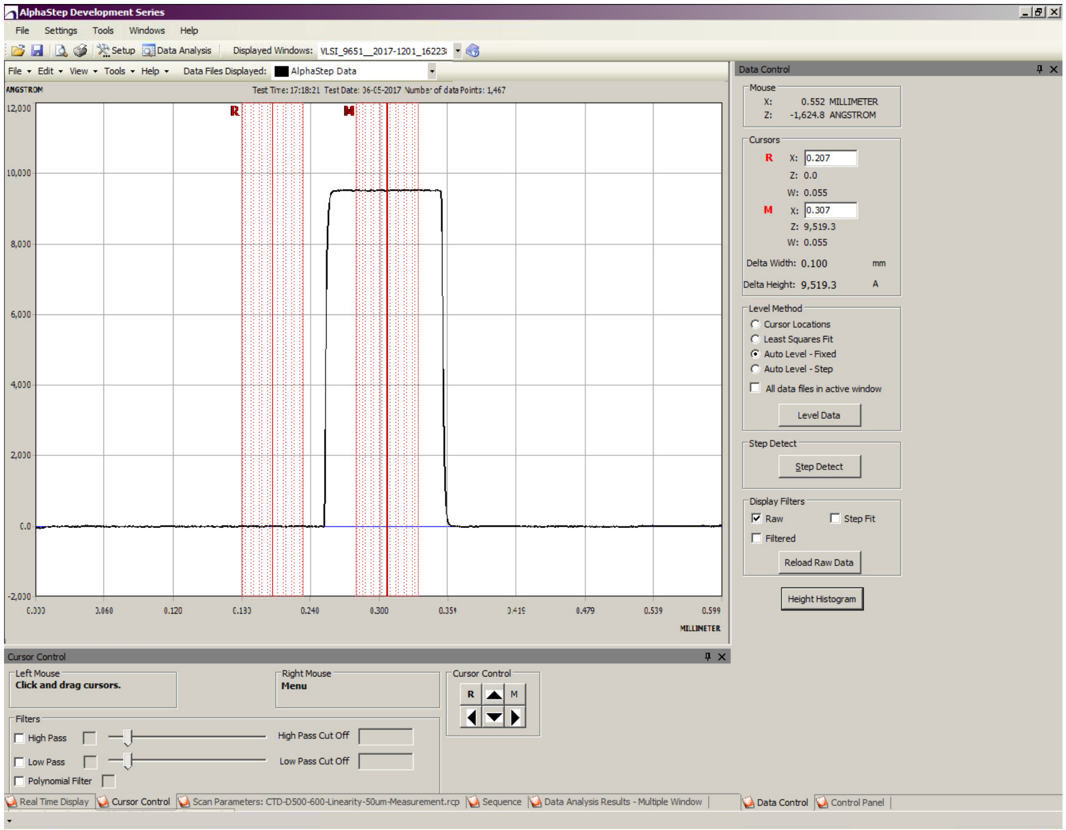
   Click the **Data Analysis** button to view the **Z(M) - Z(R)** value of the cursor positions within the scan data, or simply observe the **Delta Height** value in the Data Control panel at the right of the screen. This value must be less than 100 Å before proceeding to the next step in the calibration procedure. Adjust the scan stage tilt wheel and continue to test scans until this requirement is achieved. Refer to “Manual Stage Leveling” on page 77 for a description of the leveling process. The Figure 10-8, shows scan data resulting after proper stage leveling:

Figure 10-8 1 µm Step Measurement Feature after Precise Stage Leveling



3. Align the Step: Navigate to the toolbar and click **File > Load Scan Recipe** and open the Scan Recipe labeled **CTD-D500-600-Linearity-1um-StageLevel.rcp** This file sets the auto functions to level and measure the feature with respect to particular locations. In order to ensure accurate measurements the Y-position of the stage must be set precisely so that the center of the step-height feature aligns with the center of the scan length. Adjust the position of the step and perform subsequent test scans until the resulting scan data is displayed as shown in Figure 10-9 (centered in the middle of the scan length).

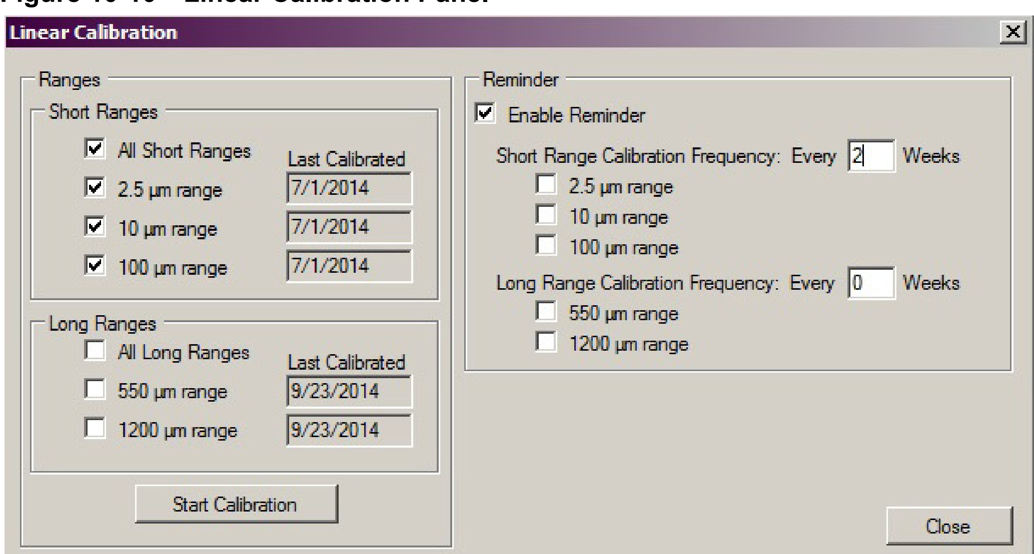
Figure 10-9   1 µm Step Height Measurement Feature



4. Begin Short Range Linearization:

   Type the L key, or select **Tools > Linear Calibration** from the tool bar, and the Linear Calibration panel is displayed as shown in Figure 10-10.

Figure 10-10   Linear Calibration Panel



Because the 1 µm step-height is only used to calibrate the Short Ranges, only the section labeled Short Ranges is of interest. Choose from among the Short Range options - individual calibrations of the 2.5 µm, 10 µm, or 100 µm ranges, or All Short Ranges. The comprehensive All Short Ranges option is always recommended and takes about 30 minutes. After the option is chosen, click **Start Calibration** at the bottom of the panel.

The user is prompted to answer two questions, ensuring that the scan-stage is level and that the scans have been properly aligned (refer to Appendix , “Long Range Calibration”). If the user selects **Yes** to both of the questions the automated routine begins.

If a scan disruption occurs more than twice during the calibration of a given range a dialog box is displays which alerts the user that the calibration setup must be verified and the test repeated.

5. End Short Range Linearization:

   After the calibration successfully completes, the dates in the panel gets updated. Close the Linear Calibration panel.

6. Z-Height Calibration:

   Perform a Z-height calibration (refer to Calibrating the Measurement Head) on any range that was calibrated for linearity in the above sections.

   Remove the 1 µm step-height standard from the scan stage.

10.2.3 Linear Calibration Details

10.2.3.1 Linear Calibration Frequency

The frequency at which the linear calibration procedure should be performed depends solely on the amount of stress experienced by the stylus/pivot mechanism. This stress is related to the demands of the user's application, and by scanning habits. As a result, there is no exact interval at which calibrations should be performed, only a set of guidelines that the user should adhere to for best results. The following sections provide insight and instruction as to when the linear calibration procedure is necessary.

10.2.3.2 Long Ranges

The Long Ranges (greater than 550 µm) are extremely robust and is remains calibrated over long periods of time, roughly on the order of months. Unlike the high gain ranges (discussed in the next section), excessive flexure or disruption of the pivot mechanism is not effecting the Long Range calibrations drastically. Within reason, anything short of a stylus change can be tolerated. If the instrument is located in an uncontrolled environment, however (such as a university or multi-purpose laboratory), it is recommended that all Long Ranges be re-calibrated once per month to ensure optimum accuracy.

10.2.3.3 Short Ranges

The two highest gain ranges (2.5 µm and 10 µm) are the most sensitive to calibration degradation. In most cases this is related to excessive flexure or disruption of the pivot mechanism. This can occur from impacting the stylus laterally; displacing the stylus to Z-heights greater than 1200 µm; or, in extreme cases by tripping the Z-stop electro-mechanical flag (a Z-height displacement of roughly 1350 µm). By simply engaging in a Step Down profile type in the 1200 µm range the stylus is displaced by 1200 µm. In any of these cases, it is recommended that the Short Ranges be re-calibrated before further measurements are made in the 2.5 µm, 10 µm or 100 µm ranges.

If the user operates safely within these limits and the pivot mechanism is flexed minimally, the Short Range calibrations might remain accurate up to a month in some cases. It is recommended, however, that calibrations be performed on all Short Ranges every two weeks if the instrument is under regular use. Increased frequency of linear calibrations is improves the accuracy of the tool.

10.2.3.4 Linear Calibration Reminders

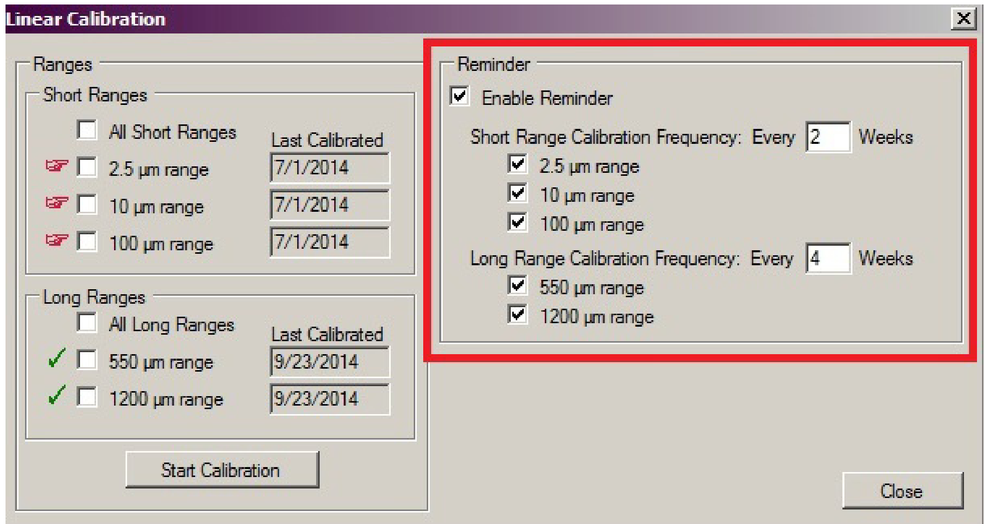
As a rule, all ranges - long and short - must be re-calibrated after a stylus change or following any maintenance of the pivot assembly. If all ranges are going to be calibrated always calibrate the Long Ranges before calibrating the Short Ranges. Provided in Table 8-1 is a list of cases when calibration would be appropriate:

Table 10-1 Typical Cases Requiring Calibration

Event	Recommendation
Installation of Instrument	Calibrate All Ranges (Long, then Short)
Stylus is changed	Calibrate All Ranges (Long, then Short)
Stylus is displaced by >1200 µm	Calibrate All Short Ranges
Z-Electrical Stop is reached	Calibrate All Short Ranges
Every 2 weeks	Calibrate All Short Ranges
Every 4 weeks	Calibrate All Long Ranges

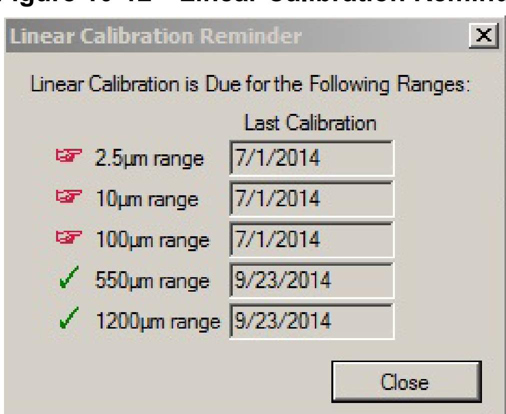
Within the right-side of the Linear Calibration Panel there are fields for defining software reminders to aid the user in ensuring regular calibration. This is shown in Figure 10-11. Type the L key, or select **Tools > Linear Calibration** from the tool bar, and the Linear Calibration panel is displayed.

Figure 10-11 Linear Calibration Panel - Software Reminders



Although KLA-Tencor's recommended calibration frequency is the default, the user can define a preferred frequency for software reminders. The reminder is a pop-up message that is displayed at the start of the Alpha Step application, and only when the calibration of a range is past due as defined by the Reminder section of the Linear Calibration Panel. If a range is out-of-date the Linear Calibration Reminder box is displayed as shown in Figure 10-12.

Figure 10-12 Linear Calibration Reminder Panel



Ranges that are out-of-date are designated by a RED pointer, while ranges that are within calibration are designated by a GREEN check mark. As the reminder is only displayed at the start of the Alpha Step software it is important not to leave it running constantly, but to close the program from time to time.

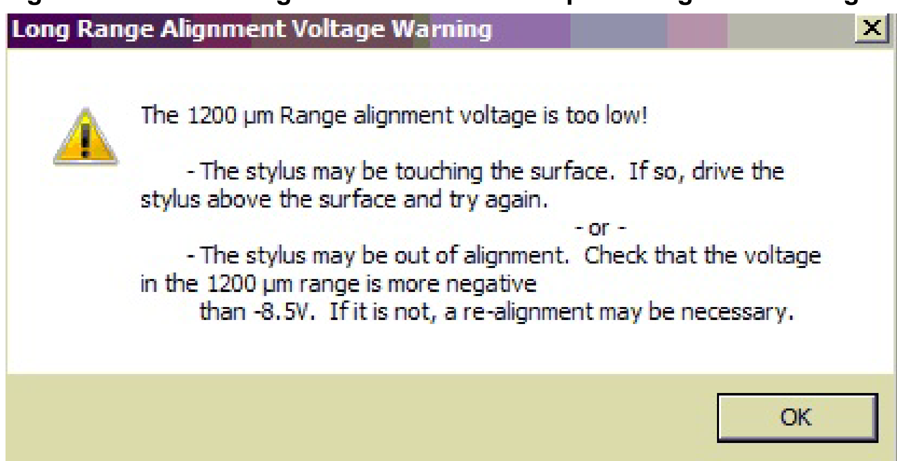
10.2.4 Troubleshooting Linear Calibration

10.2.4.1 Alignment Voltage is too Low

In order for the linear calibration to be successful the electro-optical system must be in proper alignment. When the system is properly aligned the bias position of the stylus, laser beam reflection, and photo-detectors produces a particular system voltage, called the alignment voltage. For the automated linear calibration routine to begin it is critical that the system recognize that the alignment voltage is within a certain tolerance.

Therefore, the alignment voltage is checked automatically before proceeding, and if a problem is detected the user is receiving the following message, as shown in Figure 10-13. The message specifically relates to the Long Range alignment; a similar warning message is displayed if there are detected issues with the Short Range alignment.

Figure 10-13 Warning for Error in Electro-Optical Alignment Voltage



This message is results from the stylus simply being contacted somewhere on the surface of a sample. This action naturally deflects the position of the stylus and yields a deviation from the system alignment voltage. In this case the user must drive the stylus UP and off of the sample before attempting to initiate the linear calibration routine again.

In a more serious case the alignment voltage might have changed due to some mechanical trauma experienced by the pivot assembly, resulting from a stylus crash, stylus change, an accidentally locked stylus, or some other disturbance to the stylus and/or pivot assembly. In these cases the reflected beam is miss-directed and must be re-aligned so that the proper alignment voltage is achieved. If it is suspected that the system is out of alignment a technical representative of KLA-Tencor should be contacted.

10.2.4.2 Calibration Failure

In order for the linear calibration routine to complete successfully there are two conditions required by the system. The first is that the system needs to be able to engage to every programmed location across a given range, and the second is that it must be able to analyze good scan data.

If the system cannot engage to a given location there can be a time-out and the user receives the error message as shown in Figure 10-14.

Figure 10-14 Error Message - Unable to Engage for Scan

Receiving this error message during the linear calibration routine is an indication of either an optical misalignment, or of a mechanical error in the Z-stage mechanics. In either of these cases the system is prevented from engaging properly and a technical representative of KLA-Tencor should be contacted.

During the routine the software is attempting to reject any bad scans that can arise from excessive vibration, shock, or mechanical disruption. If a scan disruption occurs more than twice during the calibration of a given range, a dialog box is displayed which alerts the user that the calibration setup must be checked and the test repeated. In this case the warning is displayed as shown in Figure 10-15 (shows the error message that arises if too many scans are corrupted during the Linear Calibration procedure).

Figure 10-15 Error Message - Scans are Corrupted

10.3 Calibrating the Measurement Head

The **Alpha-Step Development Series** profiler is calibrated before it leaves the factory. But, it is necessary to calibrate the measurement head for the specific height range that you are measuring. The following directions describe how to calibrate the instrument with a known step height standard.

The frequency of calibration is very dependent on the individual customer circumstances:

If the instrument is being used in a manufacturing environment with relatively tight process control parameters, the instrument should be monitored daily. The process engineer should regularly monitor the control charts and relative deviation of the step height to insure that daily calibration is appropriate for the process.

If the instrument is used in an R&D lab where deposition thickness is monitored by a step height weekly and the films are relatively thick, the system should be monitored monthly.

If the instrument is in a lab with several users, and it is critical to obtaining the most precise measurement possible, it is recommended the system be monitored prior to your first measurement and after the last measurement of a set for very tight calibration controls.

For more information on calibrating your system or creating a schedule for maintenance, contact the KLA-Tencor Customer Service Department.

10.3.1 Calculating the Calibration Factor

Each scan range has its own calibration factor in the registry, so the calibration should be done for each scan range separately.

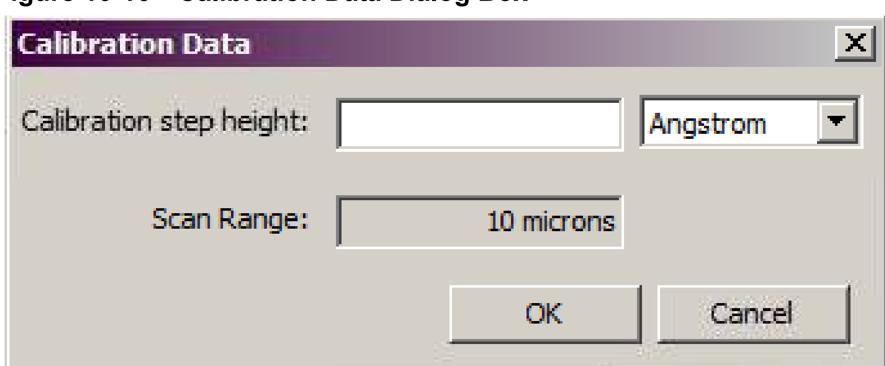
1. In the **Scan Parameters** tab, select the scan range that you want to calibrate.
2. Load onto the sample stage the height standard representative of the height range that you are measuring or the standard sample included with your system.

NOTE

Ensure that the Setup parameters are consistent with factory settings used during factory calibration as described in the certification documentation included with your system.

3. Scan the standard sample step height.
4. In the **Data Display** window, position the R and M cursors on the features of the scan that is the baseline (refer to Chapter 6, “Leveling the Profile,” on page 97 for more explanation).
5. Click **Level Data**.
6. Position the R cursor just outside a step.
7. Position the M cursor on the top of the step height feature.
8. Use the **Average Mode** for both cursors to maximize the number of data points being used to set the baseline and step height (refer to “Chapter 6, “Leveling the Profile,” on page 97) if not already done during the leveling procedure.
9. In the **Data Display** window, right-click the mouse button, select the **Calibrate Height** function.
10. The software prompts the user if the cursors are in the correct location for calibration. click **OK** if you have already positioned the cursors; click **No** to close the window and reposition the cursors.
11. In the **Calibration Data** dialog box, type the step height in Angstroms of the standard sample being measured. See Figure 10-16.

Figure 10-16 Calibration Data Dialog Box

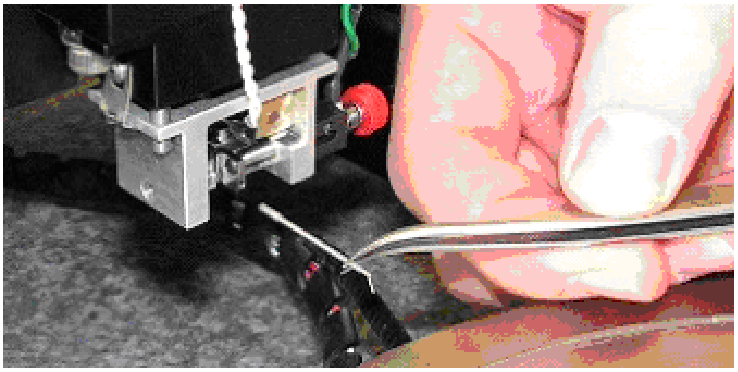


12. Click **OK**. The software calibrates the system using the measured height value.

The system is now calibrated to a known certified standard.

10.4 Changing the Stylus

Figure 10-17 Stylus Inserted into Stylus Clamp



Replacement Styli are available from KLA-Tencor.

To change the Stylus, follow these instructions:

1. Lock the pivot using the dowel plunger.
2. Using tweezers or small pliers gently grab the stylus shaft and pull the stylus straight out of the clamp.

NOTE

Be careful to not touch the diamond tip of the stylus you might cause damage and get dirt on the tip.

3. Store the old Stylus in a safe place.
4. Using tweezers grab the new stylus as shown in Figure 10-17.
5. Gently insert the stylus into the spring clamp with the flat side of the tapered end facing to the left (flat side the spring clip). You have to press fairly strongly depending on the tightness of the spring clam for that instrument. The stylus is slides into the clamp holder. Ensure that the stylus hits the back of the clamp.
6. Release the stylus lock by unlocking the dowel plunger (refer to “Unlocking the Pivot Assembly” on page 38).

NOTE

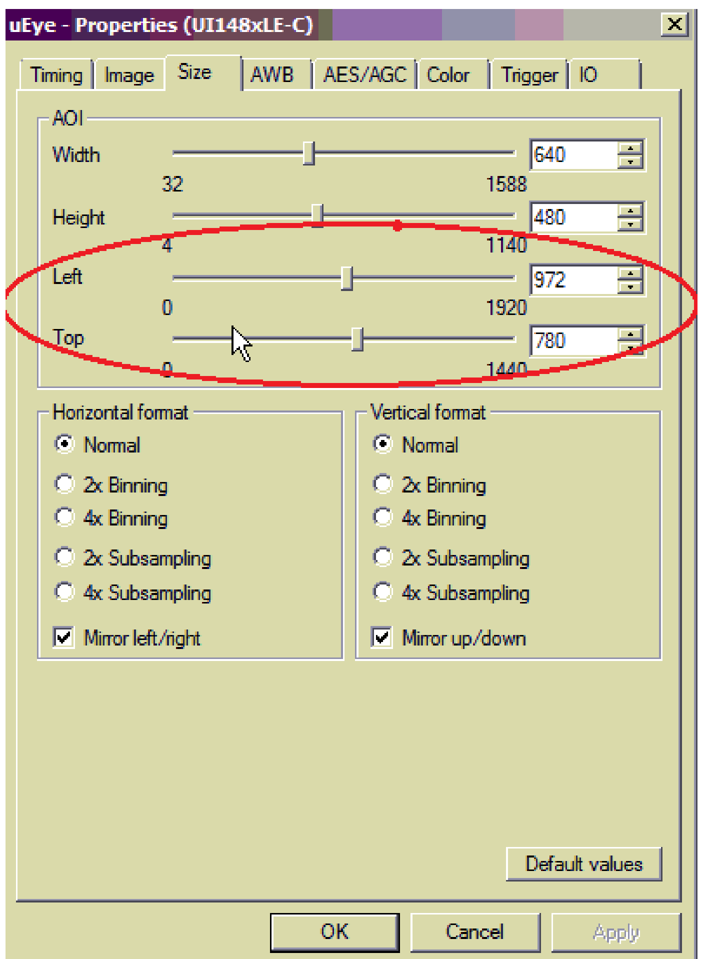
The KLA-Tencor service policy does not cover damage to the stylus, the stylus arm assembly, or the pivot caused by operator error.

10.5 Stylus Tip Centering

When the tool is installed, the stylus tip is located in the center of the video view for all the video magnifications. When a new stylus is replaced, the stylus tip could be slightly offset from the center of the video view for 1x magnification. But if the magnification is switched to 4x, the offset is more visible and this need to be corrected. The following is the procedure of how to center the stylus tip to the center of video view for magnification of 1.3x, 2x, and 4x.

1. Change the Magnification of Zoom Lens to **4X** in the **Control Panel**.
2. Focus the stylus on a sample.
3. Use **CTRL + M** to bring up Camera Utilities on top of video view.
4. Select **Camera Utilities > Open Camera Parameters** dialog box. Select **Size** tab and adjust the **Left** and **Top** offsets to center the stylus tip in the camera view as in Figure 10-18.

Figure 10-18 Camera Parameters Dialog Box



5. After the stylus tip is centered in the video view, close the **Camera Parameters** dialog box.
6. Under the **Camera Utilities**, click **Save Camera Parameters** to save the changes made.
7. Repeat the same procedure for magnification of 2x and 1.3x.

NOTE

This procedure does not work on magnification of 1x. If the stylus tip is far off from the center of the video view, first check whether the stylus is mounted correctly. If the stylus is mounted correctly and the stylus tip is far off from the center of video view for magnification 1x, contact KLA-Tencor Service Department.

10.6 Software Maintenance

10.6.1 Backing Up Files

It is a good user maintenance policy to make back up copies of the data and scan recipes. All profiler Data and Scan Recipes are stored under the software directory on the computer local disk drive C.

1. Go to the local disk drive C.
2. Double-click the **KLA-Tencor** folder.
3. Double-click the **AlphaStep D** folder.
4. Select the **Data** folder and the **Setup** folder and copy each one to a Server, CD-ROM, or other data storage device that your facility uses for backup purposes.

10.6.2 Restoring Data and Scan Recipes

Data or Scan recipes can be restored from a backup location if you did back up your data and scan recipes.

Restoring Files from a Backup Location:

1. Insert the CD-ROM, or other storage media into the appropriate drive location or use the Windows Explorer to locate the Network drive where the Data or Scan Recipes are backed up.
2. Right-click the **Data or Setup** folder to be copied. A drop-down list is displayed.
3. Select **Copy** to copy the folder to the computer Clipboard or Drag the folder to the software folder in drive C. The files are copied to their respective folders.
4. If there are already copies of the files in drive C, a prompt message indicating that the files overwrite is displayed.
5. Close the Windows Explorer program.

10.7 Help Files

The Help files are accessed from the Main software screen or on the computer desktop. To access the Help files:

1. Click the **Help** drop-down list located at the top of the Main software screen.
2. Click **Contents** to open the help window.
3. Follow the directions in the help window.

A

Profiler Specifications

Contents

A.1 Alpha-Step Development Series Profiler Specifications

Table A-2 Alpha-Step Development Series Profiler Specifications

PROFILER* SPECIFICATIONS	Alpha-Step D-600	Alpha-Step D-500
Sample Stage Diameter	200 mm	140 mm
Scan Length Range	55 mm maximum	30 mm maximum
X-Y Stage Translation	150 mm x 178 mm	NA
Sample Thickness	30 mm (~1.25 inches)	20 mm maximum (~0.75 in.)
Stage Positioning	<5 µm Motorized and Programmable	Manual
Vacuum Chuck	Standard	None
Vertical Resolution:	0.38Å Least Sig bit	0.38Å Least Sig bit
Lateral Resolution:	100 nm (Stylus dependent)	100 nm (Stylus dependent)
Vertical Range:	1200 µm max	1200 µm max
Step Height Repeatability:	5 Å or 0.1% (one-sigma), whichever is larger	5 Å or 0.1% (one-sigma), whichever is larger
Max. Data Points per Scan	400,000	400,000
Sample Viewing:	Color Camera	Color Camera
Standard Magnification:	1x, 1.3x, 2.0x. 4.0x digital zoom	1x, 1.3x, 2.0x. 4.0x digital zoom
Field of View:	13.8 mm x 3.2 mm	3.8 mm x 3.2 mm
Stylus Tip Radius:	2.0 microns (standard)	2.0 microns (standard)
Stylus Force Range:	0.03 -15 mg (programmable)	0.03 -15 mg (programmable)
Software Leveling:	Yes-cursor-controlled or Auto-Leveled (for repeated scans)	Yes- cursor-controlled or Auto-Leveled (for repeated scans)
Scan Filtering:	Low-pass, high-pass, and polynomial adjustable filter	Low-pass, high-pass, and polynomial adjustable filter
Stress Option	Yes	Yes
* Specifications are subject to change. Contact KLA-Tencor for the latest system specifications.		

Table A-3 System Configuration

System Configuration	
Microprocessor	Intel
Operating System	Windows 7 (or comparable operating system)
Interface Method	Keyboard/Mouse
Monitor	19 in. Flat Panel or equivalent
Power Requirements	115 V, 60 cycles or 230 V, 50 cycles

Revision History

Rev.	Rev. Date	Changes Made	Author/ Editor	Reviewer	Approver
AA	04/2016	Initial Release.	Mu, Weiqiang/ Balasubramaniam, Vigneshwaran	Mu, Weiqiang	Reichert, Jeff
AB	08/2017	Revised the document for the DCR T37230.	Thangaraj, Radhika	Li, Heyin	Reichert, Jeff / Li, Heyin / Liang, Jianhui
AC	12/2017	Revised the document for the DCR T39608.	Govindaraj, Chinnaraj, GSS Tech Writer	Niu, Xiaohai	Li, Heyin