Surface Measurement

User Manual

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Contents

1 Introduction

1.1 Overview

As part of the Akrometrix Studio software platform, Surface Measurement is designed as the data acquisition package for any Akrometrix hardware utilizing the shadow moiré, fringe projection, or DIC techniques. It features a multiple document interface where the user interacts with child windows and context menus allowing many types of information to be displayed and compared on screen at one time. This manual is intended for use with Akrometrix Studio 8.2.

This manual describes the interface and functions of the Surface Measurement software. Automated data acquisition during a thermal profile is described in the **Thermal Profiler User Manual** and analysis is described in the **Surface Analysis User Manual**. Surface Measurement requires system hardware to operate and, thus, will only be installed on computers attached to Akrometrix measurement equipment. Surface Analysis may reside on the measurement equipment computer and/or on a remote computer.

A user unfamiliar with shadow moiré, fringe projection, and DIC and their application in Akrometrix measurement systems is advised to first read **Akrometrix Techniques and Analysis 101**.

Section 2 describes the program interface and its functions. **Section 3** describes the program functionality while in DFP mode. **Section 4** describes the program functionality while in DIC mode. **Section 5** describes common problems and troubleshooting. **Appendix A** describes software file formats and keyboard shortcuts.

1.1 Warnings and Notes

1.1.1 Warnings and Notes in this Manual

Warnings and Notes are marked throughout the manual with these icons:

Figure 1.1 Warning Icon

Figure 1.2 Note Icon

Warnings are specific health hazards for the operator or potential sources of system damage. Notes highlight system limitations or automatic responses that may require corrective action by the operator for successful operation.

1.2 Technical Support

For technical support, contact Akrometrix:

Akrometrix 404-486-0880 support@akrometrix.com
2700 NE Expressway 404-486-0890 (fax) http://www.akrometrix.com
Building B, Suite 500
Atlanta, GA 30345

When contacting Akrometrix, please provide the system serial number, the version numbers of the Akrometrix software being used, a description of the problem or question, and contact information for reply. If the question concerns a particular measurement or analysis, please provide electronic copies of the phase images, reference images, and final results and a description of data acquisition and/or analysis conditions. If the problem concerns changes or failure in general system operation, please describe any events or system modifications that occurred immediately before the problem arose.

2 Surface Measurement

2.1 Start-up

1. Run Surface Measurement by clicking the Surface Measurement button in the Studio Manager bar on the left side of the screen. Alternatively, the program can be run from the desktop shortcut or by pointing to **Start→All Programs→Akrometrix→Surface Measurement**. A start-up splash screen appears while the software initializes.

2. When asked whether or not to home the grating stage, ensure that all obstructions are removed from the stage path and press **Yes**. If **No** is pressed, the application will continue to load without homing the sample support motors. Homing can be accomplished after program start.

Note: Pressing No will decrease program startup time. In this case, however, absolute sample support position will not be available until the motors are homed.

3. The main Surface Measurement screen will display. The parent window contains a camera view and all other windows that the program spawns.

2.2 Acquiring Data

1. Position the sample under the grating, using the Camera window (see **Figure 2.1**) to line up edges of the part so that they are more or less parallel with the edges of the camera view.

2. Adjust the region of interest, or ROI, such that it fully encompasses the part to be measured.

Note: As of Studio 8.0, multiple independent ROIs can be simultaneously acquired. For large numbers of identical parts, use Part Tracking as described in **Section 2.11**.

3. Adjust the sample/grating height using the Sample Height Adjust Window (see **Figure 2.2**) so that there is adequate fringe contrast on the sample. It may also be necessary to adjust the camera iris settings to get adequate brightness on the sample. Use the highlight saturated and dark pixels options to avoid getting saturation in the fringe image. These can be activated by going to the Camera Control window described in **Section 2.3.2**.

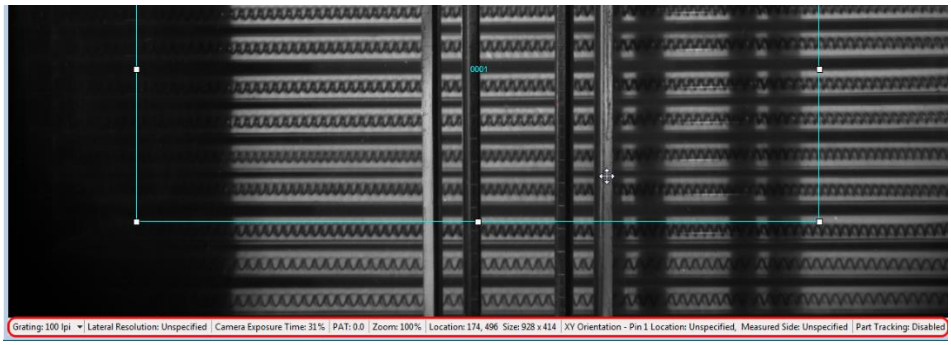

Figure 2.1 Camera Window, Information Bar Circled

Figure 2.2 Sample Height Adjust Window

4. Right-click on the Camera window to bring up a context menu (see **Figure 2.15**) that contains the Acquire… command. Click Acquire… or, alternatively, press the **F12** key.

2.3 Information Bar

At the bottom of the Camera window (see **Figure 2.1**), an information bar displays relevant acquisition parameters for quick user reference. These include

- which grating is selected (if more than one is installed on the system)
- Lateral Resolution
- the camera exposure time setting
- the phase amplitude threshold (quality mapping)
- the digital zoom setting on the camera window
- the ROI location and size, in pixels, of the currently selected ROI
- the XY Orientation; Pin 1 Location and Measured Side
- the Part Tracking ON/OFF setting

Each one of these parameters, except for digital zoom and Part Tracking, can be edited by clicking on the desired parameter. See the following sections for a brief description of each parameter and how it can be edited.

2.3.1 Grating

The grating parameter area has an arrow on the right side. When clicked, it opens a window containing the calibration routines for a grating as well as a grating editor screen. See **Section 2.8** for instructions on using the calibration routines.

When more than one grating is installed on the system, clicking directly on the grating information area brings up a grating selection menu. The user can select among the available gratings to be the active grating.

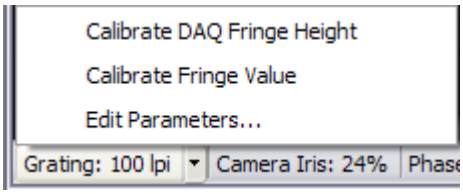

Figure 2.3 Grating Pop-Up Menu

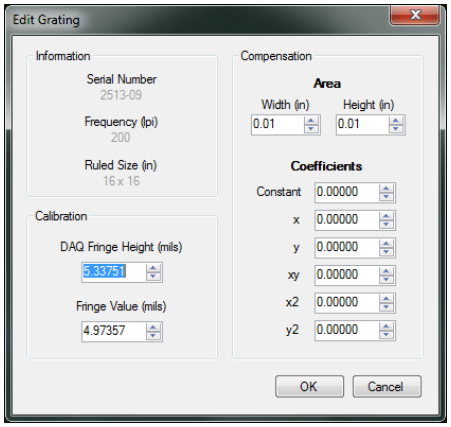

Figure 2.4 Edit Grating Window

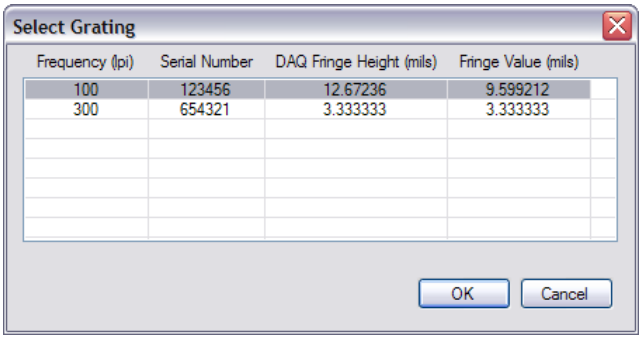

Figure 2.5 Select Grating Menu

2.3.2 Lateral Resolution

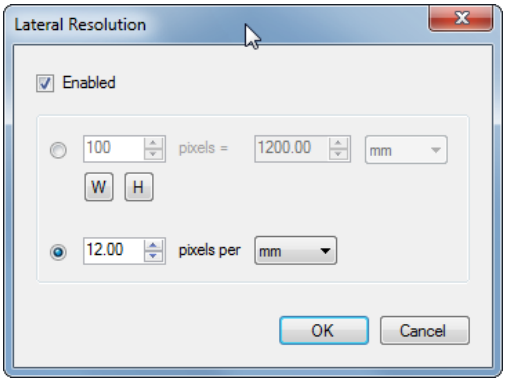

Figure 2.6 Lateral Resolution Window

The lateral resolution (number of pixels/unit area) can be defined for the current camera/lens setting. This number can be entered by using the current ROI width or height (using the W or H buttons) and a known physical width or height value from the current sample. Alternatively, if the user knows the current zoom setting that can be entered as well.

2.3.3 Camera Exposure Time

The Camera Exposure Time setting shows the current camera exposure time setting in percentage form. A Camera Control dialog can be opened by clicking on the Window menu at the top of the main screen. This dialog can control the camera exposure time setting as well as turn on and off highlighting of dark or saturated pixels.

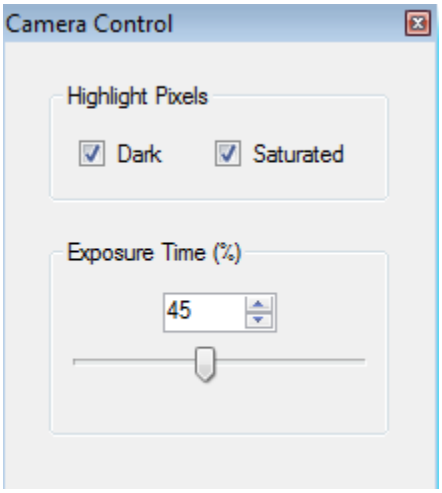

Figure 2.7 Camera Control Window

2.3.4 Phase Amplitude

This section displays whether or not Phase Amplitude Thresholding is turned on, and, if so, what its value is set to. Again, this parameter can be edited by clicking on the phase amplitude area to open a setting dialog.

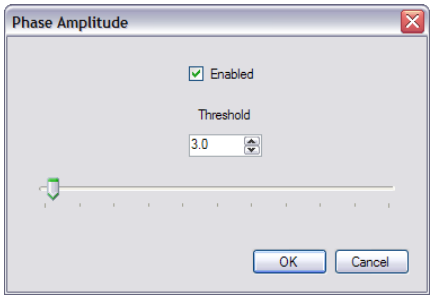

Figure 2.8 Phase Amplitude Adjustment Window

2.3.5 ROI Location

This section describes where in the field of view the ROI, or region of interest, is located and what its size is in pixels. Clicking on this area brings up a dialog that allows precise adjustment of the position and size of the ROI. If no ROI is currently selected, this section will not be present.

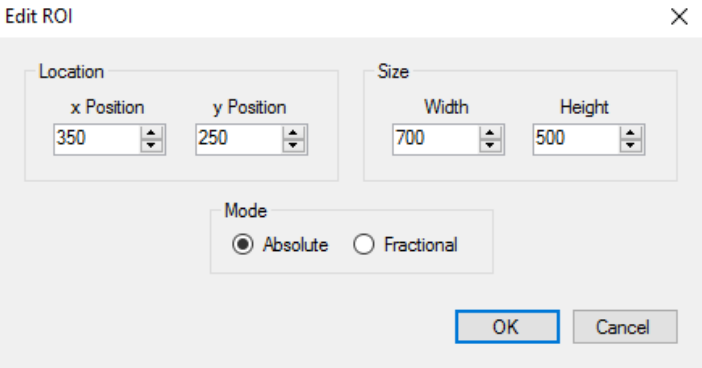

Figure 2.9 Edit ROI Window

Note: Regardless of actual ROI shape, the program models the ROI as a rectangle when reporting its size and location. Location is measured from the top left corner of the camera window to the top left corner of that rectangle.

Note: Location and size are measured in pixels in absolute mode and in fractions of the camera window in fractional mode.

The currently selected ROI can also be adjusted using the following keyboard shortcuts when it has focus. Shifting can be done using the arrow keys or the outer number keys located on the NumPad. Each press of a key results in one pixel shift of the ROI.

For example:

Up Arrow or **8** on NumPad	Move ROI up one pixel
7 on NumPad	Move ROI up one pixel and left one pixel

Holding down **Ctrl** while pressing any of these keys will increase the ROI size in the desired direction. **Ctrl+5** will make the ROI its maximum size. Holding down **Alt** while pressing any of these keys will decrease the ROI size in the desired direction. **Alt+5** will make the ROI half of the maximum length and width and position it in the center of the field of view.

2.3.6 XY Orientation

For purposes of orienting and registering surface data in Interface Analysis, a new section has been added to the Camera Window Information Bar. Clicking on this area brings up a dialog where the user can input Pin 1 Location and Measured Side of the data that is captured on Acquire.

Note: The current XY orientation setting applies to all ROIs present, including Part Tracked regions.

2.3.7 Part Tracking: ON/OFF

This section of the Information Bar simply shows whether Part Tracking is currently On or Off.

2.4 Recipes

Akrometrix recipe files contain data on various settings to ease set-up for tests which are repeated often. These files include ROI location, shape, and size, measurement operations like LSF and phase or displacement smoothing, and measurement gauges like coplanarity. Regional settings like Phase Amplitude and Smoothing can be varied between ROIs within a single recipe, or copied across multiple ROIs. Gauge and operation settings can also be varied over different acquisition temperatures if a profile has been loaded.

2.4.1 Loading and Saving Recipes

The File menu has a Recipe submenu, which contains three options as shown in **Figure 2.10**.

1. New – Creates a new recipe, resetting all settings to defaults, including one rectangular ROI in the center of the camera window.

2. Load – Loads a saved *.akx_recipe file.

3. Save – Saves current ROI settings as an *.akx_recipe file. Opens a ‘Save a Recipe’ dialog where the save location filename can be chosen.

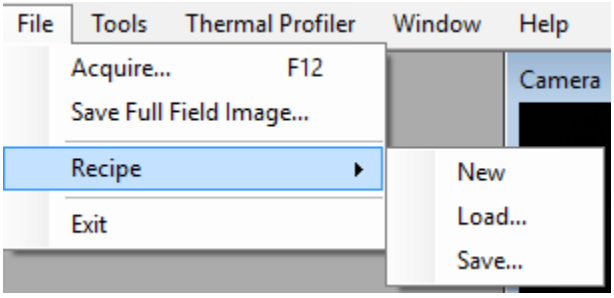

Figure 2.10 File Recipe Menu

2.4.2 Editing Recipes

The Edit Recipe dialog is shown in **Figure 2.11**. It can be accessed by right-clicking anywhere within the camera window and selecting ‘Edit…’

Note: If Edit is selected from the right-click menu of a specific ROI, Edit Recipe opens on that ROI. Otherwise, it will default to the first ROI.

The Edit Recipe dialog has 6 major sections: Menu Bar, ROI Tabs, Temperature Tabs, Operations, Gauges, and Layout.

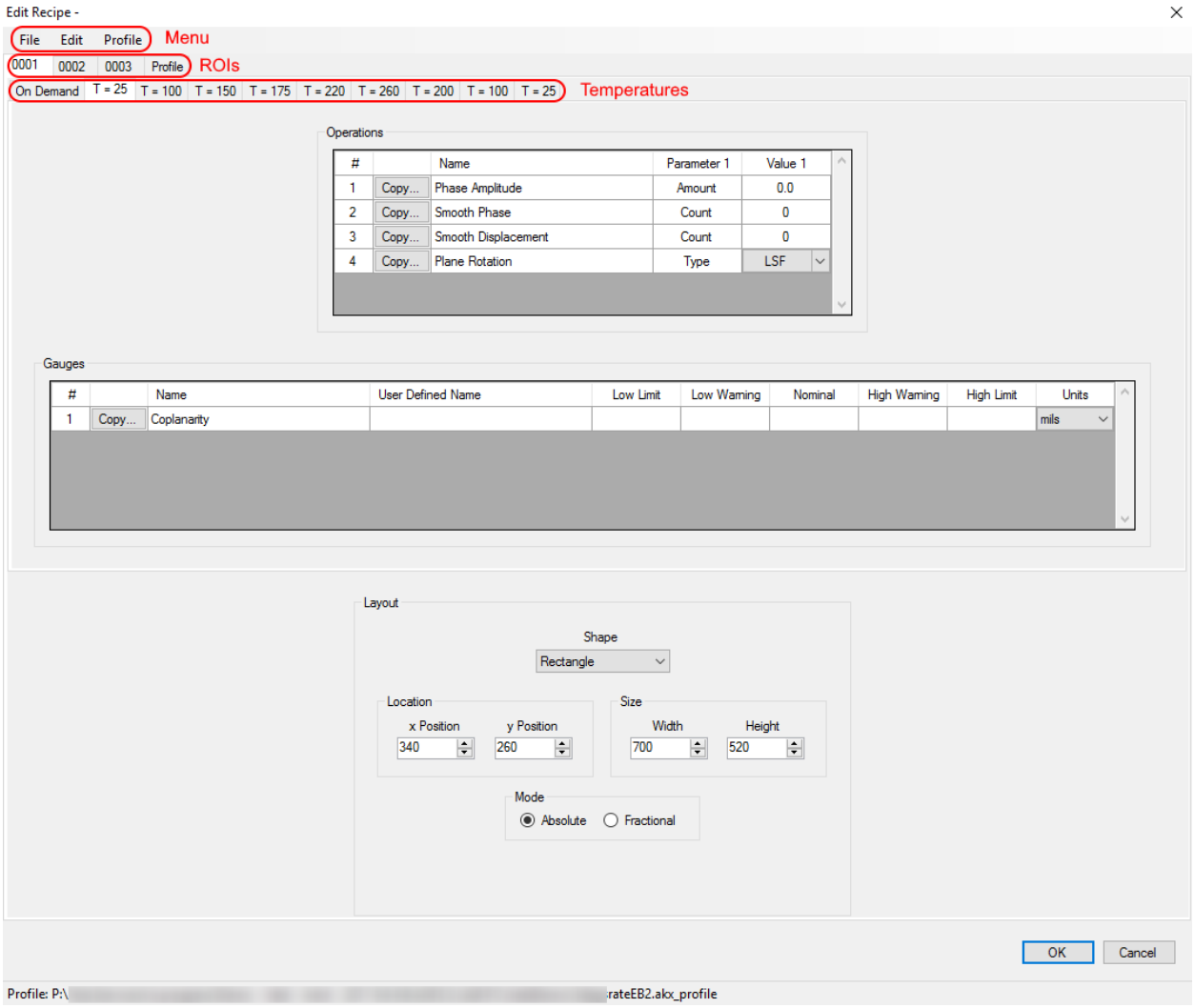

Figure 2.11 Edit Recipe Dialog

1. Menu Bar

The edit recipe menu bar has three major sections: File, Edit, and Profile.

File is similar to the Recipe section of the main menu bar, and contains options to save the current recipe or load a saved one.

The Edit menu is shown in **Figure 2.12**. Its options are detailed below.

- **Units –** Sets units in displacement plots to microns or mils. This applies both to the data and to any gauges. This value also controls unit expression in Thermal Profiler graphs.

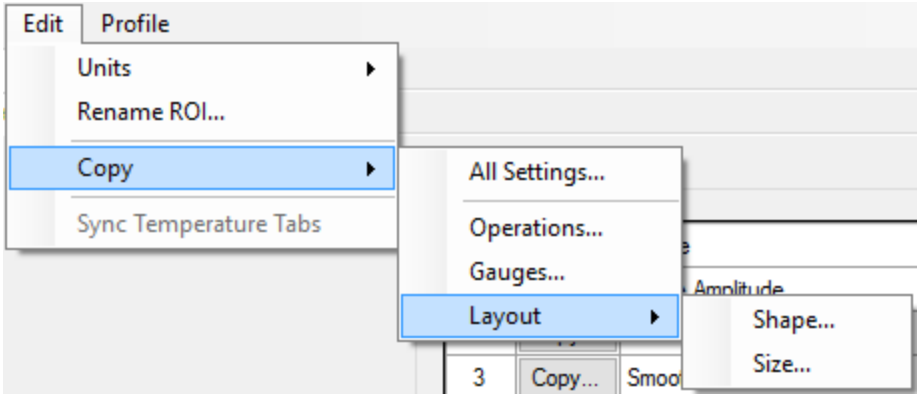

Figure 2.12 Edit Recipe Dialog - Edit Menu

- **Rename ROI… –** Renames ROI corresponding to current ROI tab (not available in Profile tab)
- **Copy –** Copies chosen settings between all ROIs. Available settings that can be copied are shown in **Figure 2.12**.

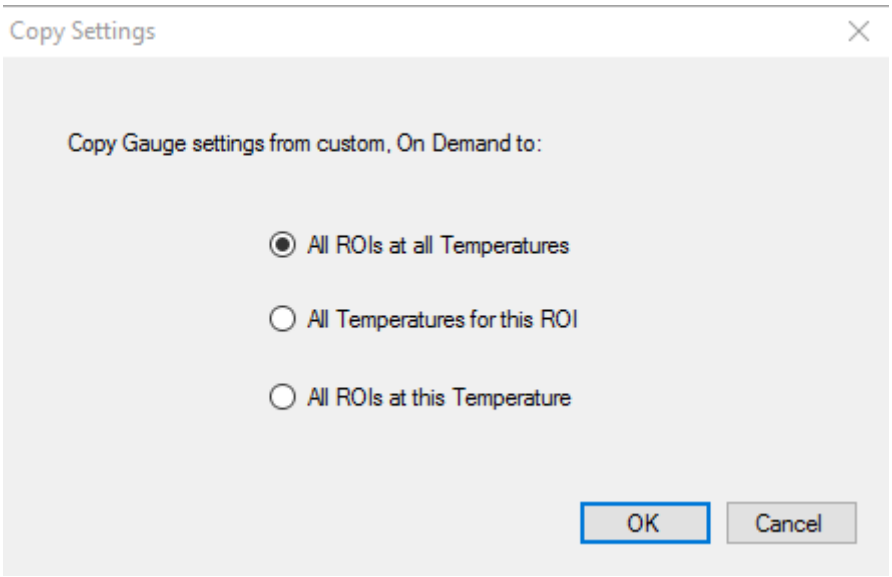

Figure 2.13 Copy Settings Dialog

- **Sync Temperature Tabs –** When this toggle is active, it syncs the selected temperature tabs between different ROIs, so that clicking between ROI tabs with a given acquisition temperature selected causes the same temperature to be selected in the next ROI tab. This does not affect setting changes.

Profile allows a saved temperature profile to be loaded into the recipe or removed from the recipe. Its third option, 'Separate Profile Acq Tabs,' is inactive unless a profile is loaded and is described below under **Temperature Selection**.

Once a profile is selected, its file path will appear at the bottom of the Edit Recipe window.

2. ROI Tabs

This is a series of tabs with each ROI name, as well as a Profile tab, if one has been loaded. If Part Tracking is enabled, a 'Tracked Parts' tab becomes available. These tabs allow the settings for each ROI to be independent of one another but can be synced in various ways using the Copy Settings Dialog shown in **Figure 2.13**.

3. Temperature Selection

If no profile is loaded, this section will contain only one tab: On Demand. Without a loaded profile, the recipe only holds settings for independent acquisitions for each ROI. If a profile is loaded but 'Separate Profile Acq Tabs' is not selected, there will be a second tab, 'Profile Acqs', for ROI settings during the profile run.

With a profile loaded and 'Separate Profile Acq Tabs' selected, this section will have a tab for each acquisition labeled by temperature in addition to the On Demand tab, as shown in **Figure 2.11**. By selecting temperatures here, the user can independently adjust the measurement operations for each ROI at various acquisition temperatures.

4. Operations

This section displays a list of four possible operations: Phase Amplitude, Smooth Phase, Smooth Displacement, and Plane Rotation. Each operation has a default value – LSF for Plane Rotation and 0 for the others.

The operation value can be edited by double clicking the numbers and entering new values, or, for Plane Rotation, by choosing a different option from the drop-down list. Editing these default values changes the operation for a given ROI. Each operation also has a copy button which can propagate its settings to other ROIs or other temperatures within the ROI.

If any operation value is unique within a temperature, ROI, or both, the cell color will change. The color codes are listed below.

- **White –** Universal setting
- **Orange –** Setting exists for all ROIs at the same temperature point.
- **Teal –** Setting is unique to a given ROI but exists at all temperature points for that ROI
- **Purple –** Setting is unique to a single ROI at a single temperature point, or setting is shared by multiple ROIs or temperatures, but not universally by temperature or ROI.

Note: The colors mark that a unique value exists, not which ROI contains that value. For example, changing one phase amplitude value in a new recipe turns all phase amplitude values purple, even though only one has been changed.

5. Gauges

Similar to Operations, this section displays a list of current gauges, along with a copy button to propagate changes to other ROIs. Gauge values use the same color codes to

mark uniqueness as Operations do. Editing gauge settings in the recipe requires a Real Time Analysis license to access Pass/Warning/Fail functionality in Surface Measurement.

Note: Real Time Analysis has to be active to see gauge results in acquisition, but gauges can be edited in the recipe even if Real Time Analysis is not toggled on.

Currently, the only available gauge for Real Time Analysis is Coplanarity. As with Operations, the user can activate and alter this gauge by changing its settings. The first editable gauge setting is User Defined Name, which applies a custom label to a gauge. Editing this changes gauge name wherever it appears, including the 3D graph pane. The user can also set low and high warnings and failure limits for the gauge, as well as a nominal value for their own reference.

6. Layout

This tab allows the user to view and change the size, location, and shape of each individual ROI. Size and shape can be copied from the edit menu, but location cannot. Location, width, and height can be displayed in absolute or fractional mode, just like ROI size and location on the Information bar.

The shape options are Rectangle, Ellipse, RoundRectangle, Diamond, and Triangle.

Note: RoundRectangle has a set corner radius of 10 pixels.

Note: Triangle is always isoceles, with the third leg oriented horizontally.

2.5 Camera Window Context Menu

There are several different commands that can be issued when interacting with the Camera window in Surface Measurement. These commands can be accessed by right-clicking within the Camera window. A slightly different set of commands can be accessed by right-clicking on a specific ROI. A full list of the available commands is below.

- **Context Menu (clicked outside an ROI)**
  - Acquire… **F12**
  - Part Tracking
  - File
  - Edit…
  - Add Region **Ctrl+R**
  - Paste **Ctrl+V**
  - Default ROI Prefix…

- Lock Layout
- Zoom
- Save Full Field Image…
- Open Thermal Profiler… **Ctrl+T**

- **Selected ROI Context Menu**
  - Acquire… **F12**
  - Zoom to Region
  - Copy **Ctrl+C**
  - Square Bounds
  - Delete **Del**
  - Delete All
  - Edit…

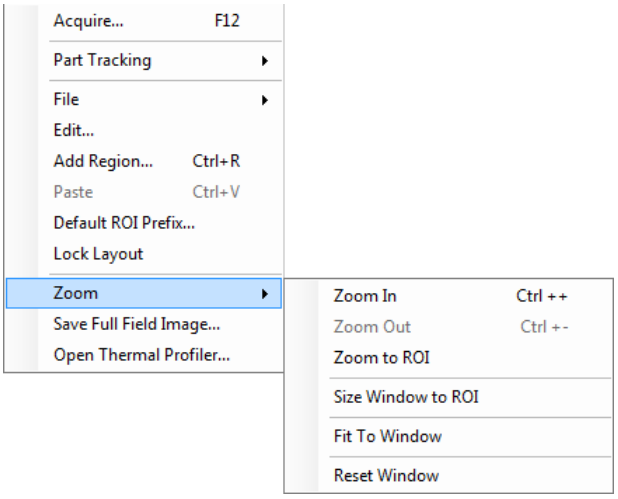

Figure 2.14 Camera Window Context Menu - Zoom

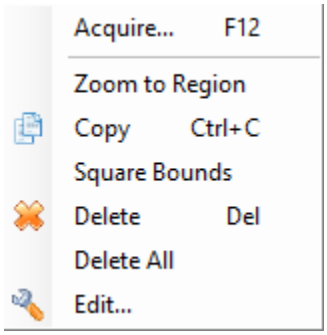

Figure 2.15 Camera Window Context Menu – Selected ROI

2.5.1 Acquire

The Acquire command performs a onetime phase image capture.

2.5.2 Part Tracking

From this submenu the user has three options: Enable Part Tracking, Assign Model, and Track Parts. These options are described in greater detail in **Section 2.10**.

2.5.3 File

Allows the user to save, load, or create an Akrometrix recipe file as described in **Section 2.4**.

The user also has the option to import an *.akx_partition file. The current recipe will be replaced with the regions from that file, and the user can choose whether the imported regions are scaled to the camera window.

2.5.4 Edit…

Opens the edit recipe menu described in **Section 2.4**.

2.5.5 Add Region

Adds a new ROI to the window that can be independently edited.

2.5.6 Paste

Pastes a previously copied ROI with the same settings, including location.

2.5.7 Default ROI Prefix…

Allows the default prefix for ROIs to be edited. This will apply to any ROIs created after the prefix is set, and will restart ROI numbering from X0001, where X is the chosen prefix.

2.5.8 Lock Layout

If toggled on, locks the layout so that ROIs cannot be changed or added. ROIs can still be deleted.

2.5.9 Zoom

Allows the Camera Window to be digitally zoomed and resized in various ways.

2.5.10 Save Full Field Image

This command will save an image in *.png format of exactly what the user sees within the Camera window, ROI included.

2.5.11 Open Thermal Profiler

This command opens a separate application in the Studio Suite called Thermal Profiler. This allows automated data capture while subjecting the sample to a thermal profile. For more details please see the **Thermal Profiler User Manual**.

2.5.12 Zoom to Region

Zooms the camera view to the region of the selected ROI.

2.5.13 Copy

Copy the settings, including location and size, of the selected ROI.

2.5.14 Square Bounds

Forces the ROI to be square using the smaller of its two dimensions.

2.5.15 Delete

Deletes the selected ROI.

2.5.16 Delete All

Deletes all ROIs.

2.6 Results Window

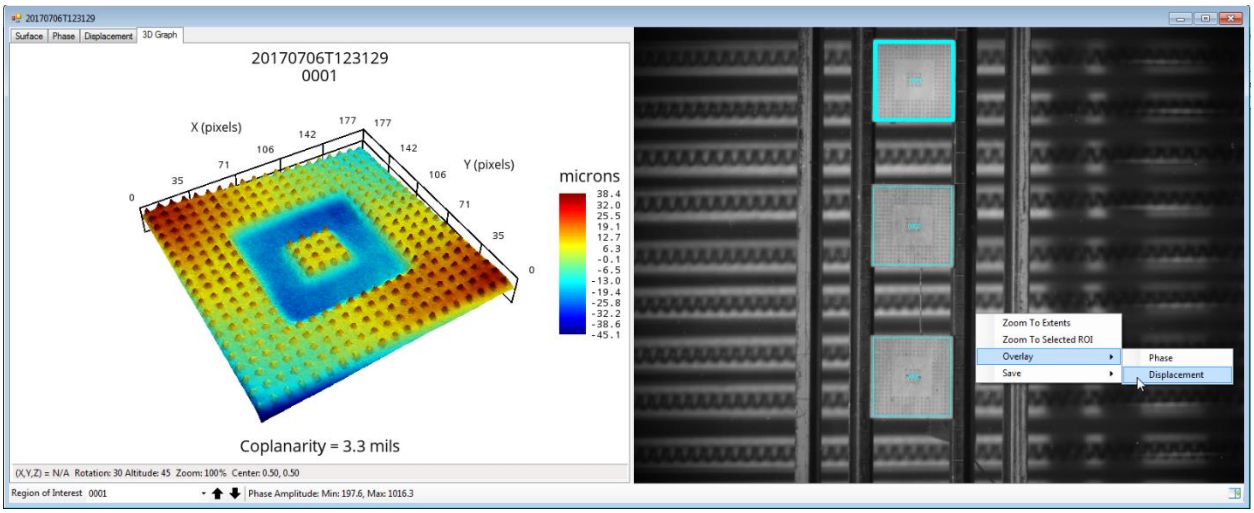

Figure 2.16 Results Window

Phase and Displacement data are displayed after acquisition in a multi-port window with tabs for different data display types. There are several different commands that can be issued when interacting with the Results Window. These commands can be accessed by right-clicking within either the camera side or data side of the window.

The Results Window can display results for all currently tracked ROIs. To switch between ROIs in the data side, either click on the desired ROI in the camera side or use the arrows at the bottom of the data side display to move between ROIs. The active ROI will be highlighted in the camera side display.

2.6.1 Camera Side Display

This section of the window displays the camera surface image and all ROI locations, including any found via Part Tracking. The view can be zoomed to the extents of the ROI locations. Phase or Displacement data can be overlaid on the surface image at the ROI location or locations in the case of Part Tracking. Lastly, the current image or overlay can also be saved.

2.6.2 Data Side Display

The data display side of the window has 4 tabs, as well as an information bar at the bottom. The information bar displays the current ROI on a selection dropdown, two arrows that switch between multiple ROIs, and a readout of the minimum and maximum phase amplitude that allows a user to quickly assess the data.

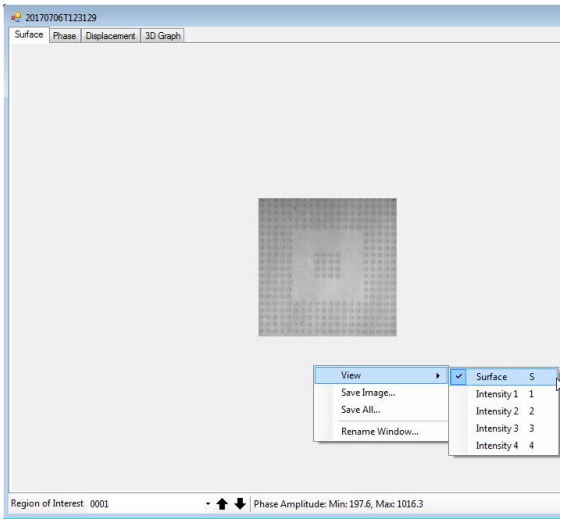

Figure 2.17 Data Side - Surface Tab

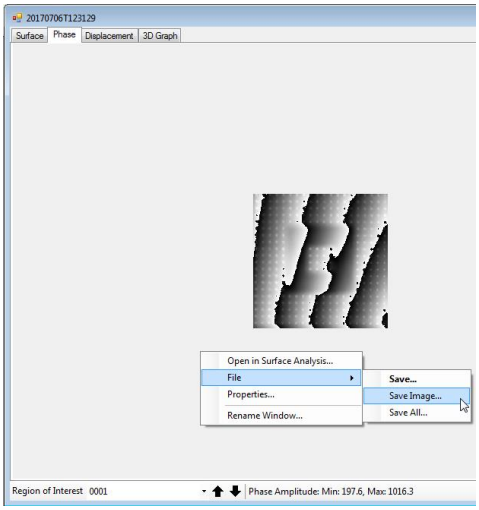

Figure 2.18 Data Side - Phase Tab

2.6.3 Surface Tab Context Menus

- View→Surface Or Intensities 1-4
- Save Image… **Ctrl+I**

Saves the surface image as a *.png image file.

- Save All…

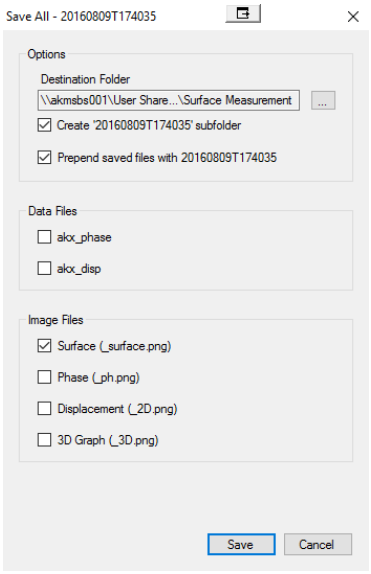

Figure 2.19 Save All Dialog

The Save All dialog allows the user to save all available data types from the Results Window at once. In Part Tracking mode, this allows all found regions to be saved as well.

- Rename Window…

Allows the user to rename the Results Window to something other than the default date/timestamp.

2.6.4 Phase Tab Context Menus

- Open in Surface Analysis…

Opens the phase image in Surface Analysis. The file is not saved to disk at this point so the user will still need to save the image if long term storage is required.

- File→Save…

Saves the phase image as a *.akx_phase file which can be analyzed using Surface Analysis. The phase image name is constructed from the date and time at acquisition, but can be changed by the user

- File→Save Image…

Saves the phase image as either a *.png or *.tif image file.

- File→Save All…
- Properties…

Opens the metadata view for the phase data associated with the acquisition.

- Rename Window…

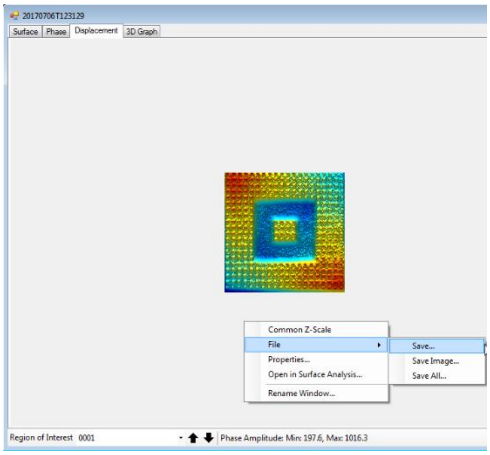

Figure 2.20 Data Side - Displacement Tab

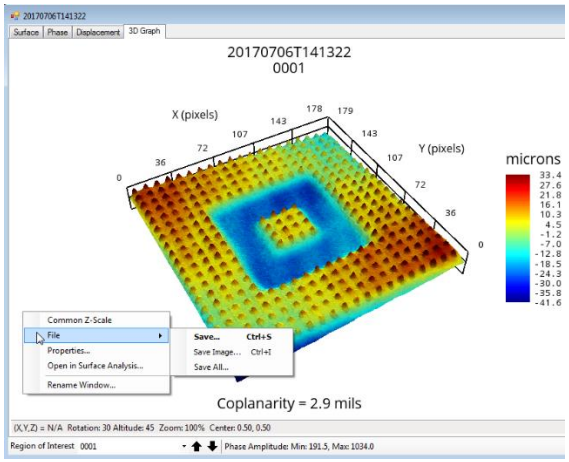

Figure 2.21 Data Side - 3D Graph Tab

2.6.5 Displacement Tab Context Menus

- Common Z-Scale

Sets all current displacement data to the same Z-scale. This option is not available when there is only one ROI.

- File→Save…

Saves the displacement data as a *.akx_disp file which can be analyzed using Surface Analysis. The displacement file name is constructed from the date and time

at acquisition, but can be changed by the user. The displacement data can also be saved for use in external programs in the *.dat or *.txt formats.

- File→Save Image…

Saves the displacement image as a *.png image file.

- File→Save All…

Opens the Save All… dialog described above.

- Properties…

Opens the metadata view for the displacement data associated with the acquisition.

- Open in Surface Analysis…

Opens the 3D surface image in Surface Analysis. The file is not saved to disk at this point so the user will still need to save the image if long term storage is required.

- Rename Window…

2.6.6 3D Graph Context Menus

Same as Displacement Tab above.

2.7 File Menu Bar

At the top of the Surface Measurement application window there is a standard Windows File Menu bar (see **Figure 2.22**). It contains the following menu categories:

- File
- Tools
- Thermal Profiler
- Window
- Help

2.7.1 File

The File menu will change depending on what type of window has focus. It will have relevant commands for the currently selected window type. For example, if the Camera window is selected, it contains an Acquire command, a Save Full Field Image command, a Recipe command (see **Section 2.4** for details), and an Exit command.

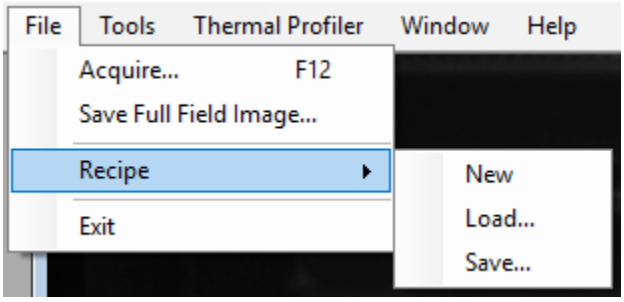

Figure 2.22 File Menu

2.7.2 Tools

The tools drop down menu contains several items, as described below.

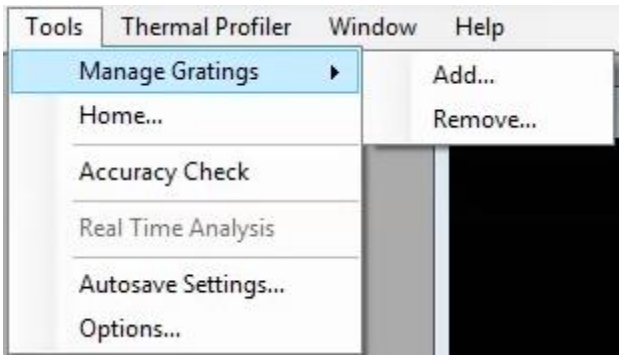

Figure 2.23 Tools Menu

- **Manage Gratings –** Allows the user to add or remove gratings from the system.
- **Home…** - Allows the user to home the system motors if that step was skipped during program start.

Note: Absolute motor position is not available unless the motors have been homed. Some features in Thermal Profiler, like frame compensation in CRE mode and lower while heating require the motors to be homed before they are available.

- **Accuracy Check –** Allows the user to check the measurement accuracy of a normal step height block (see **Section 2.8.3**).
- **Real Time Analysis –** Activating this toggle requires a Real Time Analysis license. When it is active, the user can set pass/warning/fail limits in the recipe (see **Section 2.4.2**) and determine immediately whether the analyzed parts have gone beyond acceptable bounds. In the camera window after acquisition, ROIs will be colored red (Fail), yellow (Warning), or green (Pass) based on the gauges instead of the default blue. When this is active, the Gauge Results Summary also becomes available (see **Section 2.7.4**)
- **Autosave Settings –** Allows the user to control autosave settings for phase and displacement measurements acquired in this program. Metadata settings can be used to populate filenames, as shown in **Figure 2.24**. See **Appendix A.1.1** for available Metadata fields.

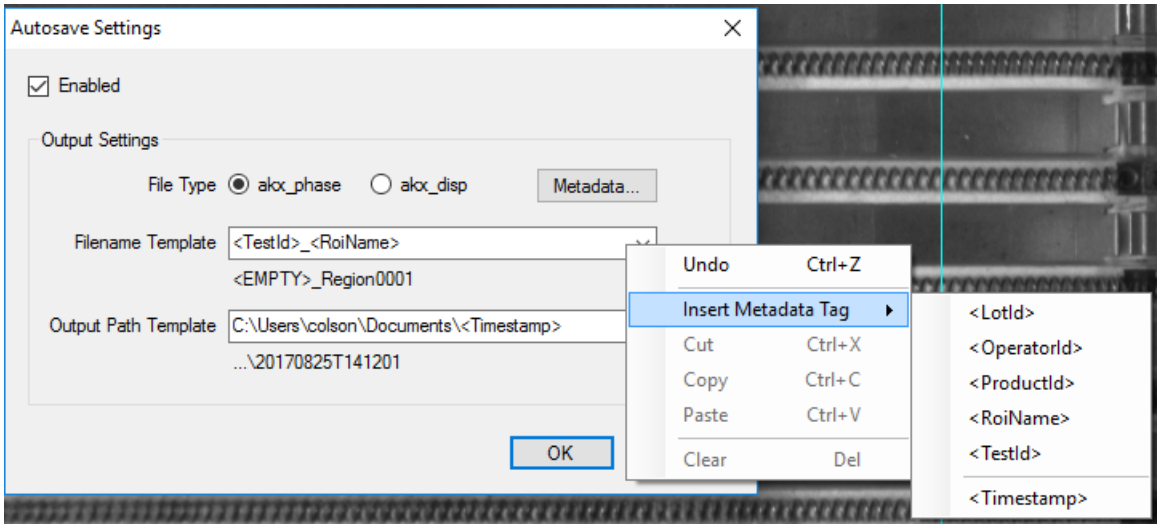

Figure 2.24 Autosave Settings

- **Options… -** Opens system options as described in **Section 2.9**.

2.7.3 Thermal Profiler

As **Figure 2.25** shows, this menu allows the user to open Thermal Profiler.

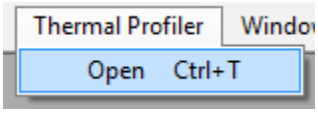

Figure 2.25 Thermal Profiler Open Menu

2.7.4 Window

This menu item contains commands for managing the child windows that are present within the parent Surface Measurement window at any time. Windows that may be hidden behind other windows can be brought to the foreground by selecting them in this drop down menu. All open windows can also be closed by selecting the **Close All Windows** command. The Metadata, Camera (**Section 2.2**), Sample Height (**Section 2.2**), Camera Control (**Section 2.3.2**), and Part Tracking (**Section 2.10**) windows are always available in this menu.

The metadata window is shown in **Figure 2.26**, and can also be accessed by pressing **F4**. It allows the user to set metadata values, which are useful in populating filenames and organizing data, for the samples being measured. This window also allows the user to set certain metadata values as required. Required metadata values are cleared after each acquisition, and must be entered for more acquisitions to be taken. This function therefore automatically reminds the user to update metadata settings between acquisitions.

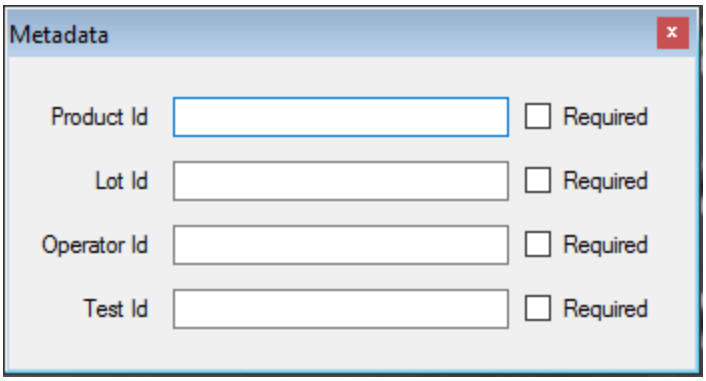

Figure 2.26 Metadata Window

When the results window is open, an option appears at the bottom of the Windows menu to bring it to the front. This option has the name of the results window – a time stamp by default, unless changed by a user. It is visible in **Figure 2.27**.

When Real Time Analysis is active, an additional window, Gauge Result Summary, becomes available. It will appear on the Window menu under Part Tracking, and can also be opened by pressing **F11**. Opening Gauge Result Summary produces the interface shown in **Figure 2.28**. It will show the gauge results for all ROIs for all acquisitions since the most recent change in the ROI settings. The Options menu allows the user to copy or reset the gauge data, or export it to Excel. In the Gauge menu, the user can choose between any active gauge or a combination of all of them. The part passes if it passes all gauges, and fails if it fails any.

Figure 2.27 Window Menu

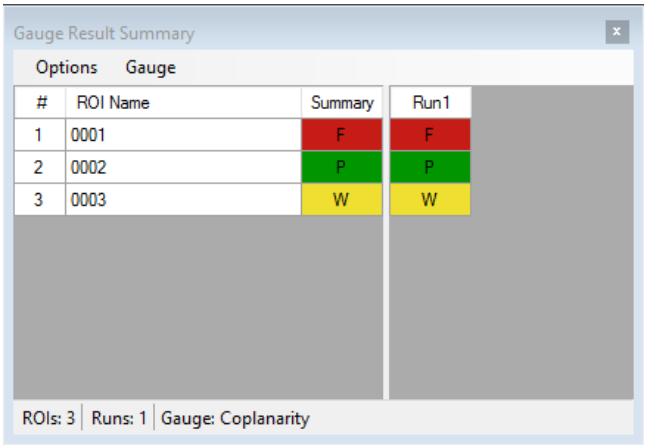

Figure 2.28 Gauge Result Summary

2.7.5 Help

This menu item contains a link to the **Surface Measurement User Manual**, the End User License Agreement (**EULA**), and an **About…** command for determining program version information.

2.8 Grating Calibration Routines

The grating calibration routines can be accessed by clicking the small arrow to the right of the Grating information area on the Information bar (see **Figure 2.29**). Clicking on

either one of these items will put the system in the respective calibration mode. The user must deselect the calibration mode when calibration is complete.

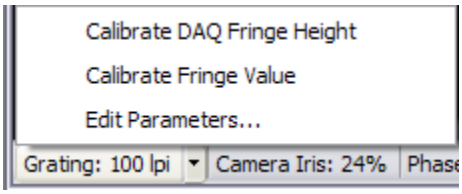

Figure 2.29 Grating Pop-Up Menu

2.8.1 DAQ Fringe Height

In the **Calibrate DAQ Fringe Height** mode, a uniform white colored continuous surface sample is used to determine the optimal phase step distance based on the optical configuration of the system. The calibration sample is provided by the user and can be any white colored, continuous surface sample that is at least 100mm x 100mm. The sample must also be sufficiently stiff so as to maintain its shape while phase stepping occurs.

1. When **Calibrate DAQ Fringe Height** mode is enabled the ROI bounding box becomes a dashed outline.

2. After placing a uniform white colored continuous sample in the measurement system, adjust the ROI such that it only encompasses a continuous part of the sample.

3. Right click to select **Start Calibration…** from the Camera window context menu. A series of images is taken with different step heights to determine the best calibrated phase step distance, or **DAQ Fringe Height**. While the images are being taken a dialog (see **Figure 2.30**) pops up showing the captured images and a plot of the intensity standard deviation for each step height trial.

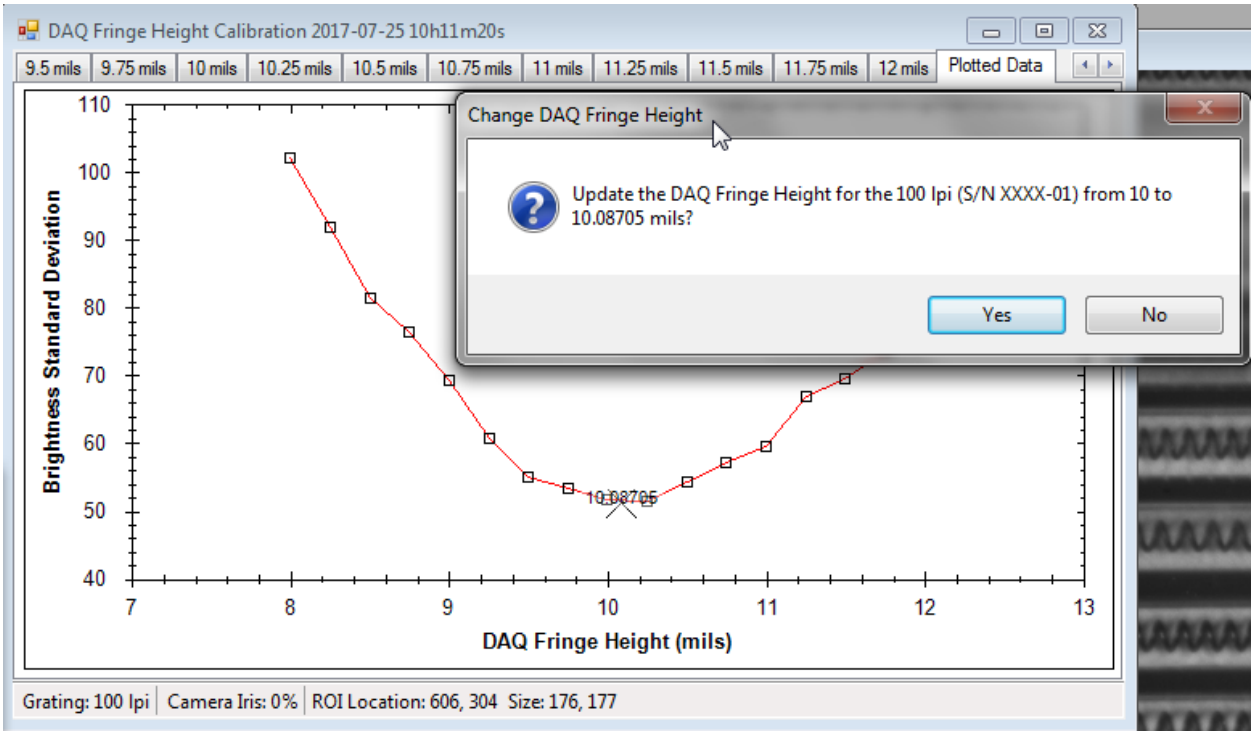

Figure 2.30 DAQ Fringe Height Cal Dialog

4. At the completion of the calibration routine a dialog pops up asking the user to update the **DAQ Fringe Height**.

Note: The DAQ Fringe Height plot should be roughly parabolic in shape. If there is no distinct minimum, vibration or some motor stepping error could be present.

5. Press **Yes** to approve and save the new **DAQ Fringe Height**. If an error is suspected (refer to **Section 5.1**), press **No** to discard the new calibration value.

Note: The resulting value should be roughly equivalent to the grating pitch.

2.8.2 Fringe Value

In the **Calibrate Fringe Value** mode, a single step calibration block is used to determine the **Fringe Value** calibration constant for the system. This block is provided with the measurement system. See **Akrometrix Techniques and Analyses 101** for more details on this calibration constant.

1. Enter the calibration offset value in the Calibrate Fringe Value dialog box (**Figure 2.33**) that pops up and click OK. The calibration offset value for the block is on the Calibration Certificate provided with each block. Please note that the relevant

number will either be listed as “Distance” or “DIST_A_to_B” depending on what independent lab was used to calibrate the block. Please see **Figure 2.31** and **Figure 2.32**.

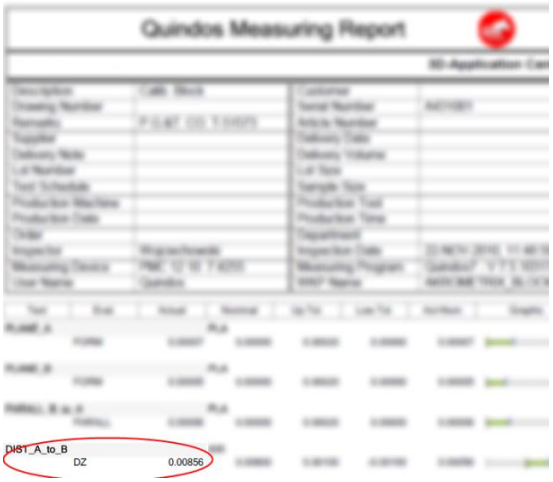

Figure 2.31 Offset Value from Certificate (Quindos)

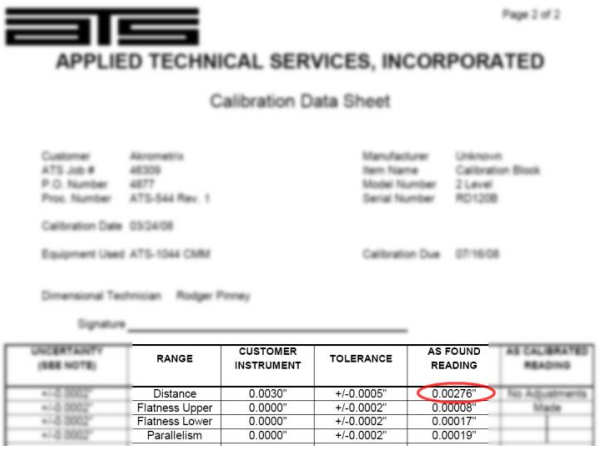

Figure 2.32 Offset Value from Certificate (ATS)

2. Adjust the ROI such that the outside square approximately outlines the calibration block (**Figure 2.34**). Exact alignment is not required because measurements are made only within the inner two rectangles, which are inset from the outside boundary.

Note: The calibration block step needs to run horizontally, or from left to right when looking down from the user’s position at the machine, but it does not matter whether the top or bottom step is in front or back.

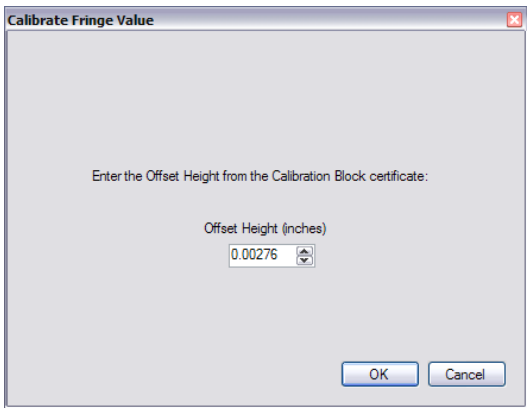

Figure 2.33 Offset Value Dialog

Figure 2.34 Fringe Value ROI on cal block

3. Right click within the ROI and click **Acquire…** The calibration process is initiated and a result window pops up afterward (**Figure 2.35**), showing the user entered

value, the measured value, the old Fringe Value, and the proposed new Fringe Value.

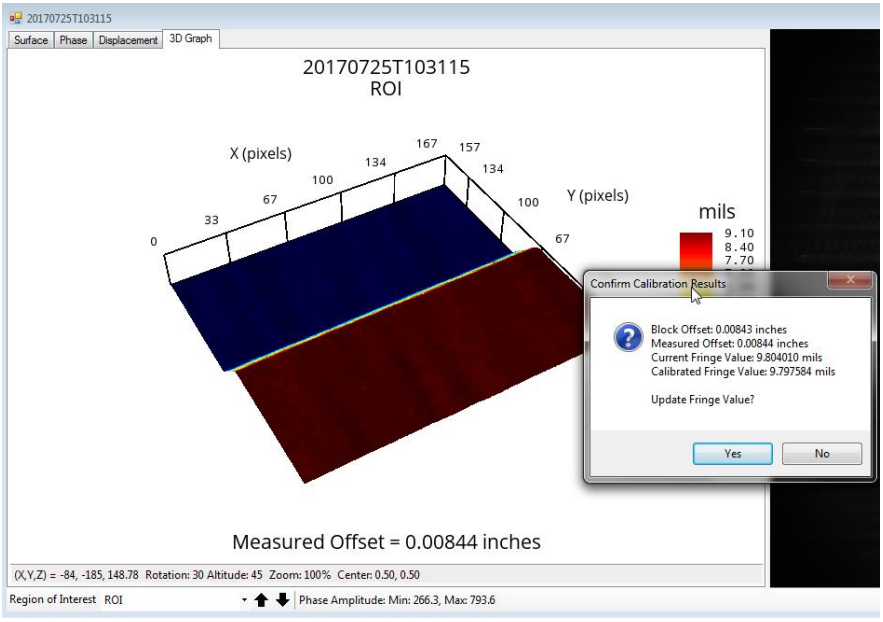

Figure 2.35 Fringe Value Result

4. Press **Yes** to approve and save the new Fringe Value. If an error is suspected (refer to **Section 5.1**), press **No** to discard the new calibration value.

Note: The Fringe Value should be roughly equivalent to the grating pitch. If the routine is performed more than once, the value should vary less than the grating resolution (± 0.1 mils or 2.5 microns). If it does not, then vibration or some motor stepping error could be present.

2.8.3 Accuracy Check

Under the **Tools** menu at the top of the program there is an **Accuracy Check** function, which is used for checking the normal height between two surfaces. This is useful for checking system accuracy against a cal block with a machined step height in it. Typically, the accuracy check measurement is compared with that of a CMM or laser based profilometer measurement.

2.9 Software Options

Surface Measurement options can be accessed by going to Tools → Options. A Dialog appears as in **Figure 2.36**.

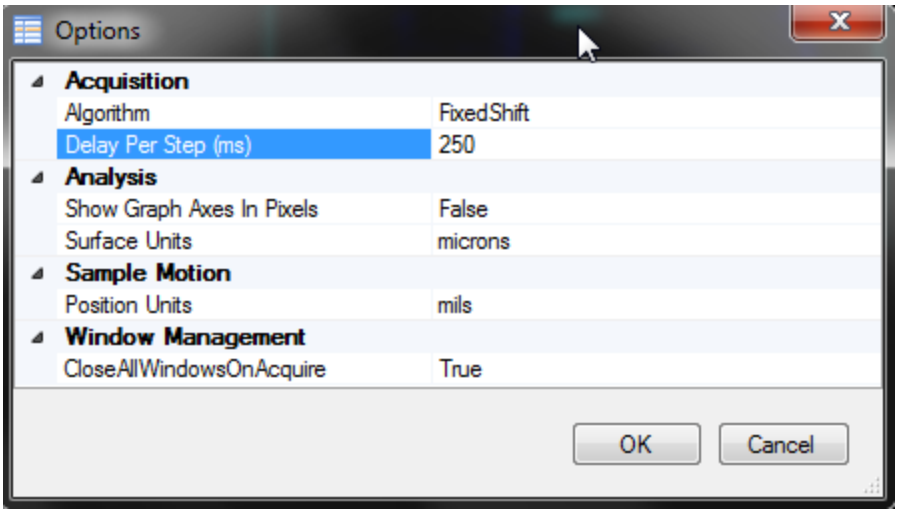

Figure 2.36 Options Dialog

2.9.1 Algorithm

Allows the user to specify either the Fixed Shift or Random Shift phase shifting algorithm. See **Akrometrix Optical Techniques and Analyses 101**. The default is Fixed Shift and is the correct choice in most situations.

2.9.2 Delay per Step

Determines the amount of time in milliseconds the software waits between each phase step. Increasing this value can be useful for samples that exhibit excessive vibration between each phase step. Keep in mind, however, that increasing this value will increase total data acquisition time.

2.9.3 Show Graph Axes In Pixels

If Lateral Resolution has been specified, the default setting of False will show 3D graphs' x and y axes in physical units instead of pixels.

2.9.4 Surface Units

Determines what units the Surface Windows display in. Options are mils or microns.

2.9.5 Position Units

Determines what units the Sample Height dialog displays the current motor travel position in. Options are mils or microns.

2.9.6 Close All Windows on Acquire

On Acquire, closes all open result windows within the Surface Measurement parent window. Setting this to false will spawn a new result window on each Acquire.

2.10 Part Tracking

Part Tracking is a feature in Akrometrix Studio which has the potential to reduce analysis time of multiple part runs by more than 90%. It is designed to find and track rectangular or elliptical parts of a user defined size at room temperature and during a temperature profile. Traditionally, if a part happened to shift or rotate during a thermal run, the user would need to spend many painstaking minutes manually partitioning and rotating the data such that the resulting displacement plots did not have any artifacts. With Part Tracking, all the resulting data at the end of a thermal run should automatically be partitioned and rotated to the same starting orientation, greatly speeding analysis time. Part Tracking even improves work flow and productivity when only one sample is tested and moves due to thermal expansion. The more samples tested at once, the more productivity will be improved.

2.10.1 Part Tracking Window

- **Shape** – Defines the shape and size of the model that Part Tracking will try to find parts with. The model shape and size is represented by the white box on the right side of the Part Tracking window.
    - **Shape** – The part shape can be selected from this drop-down. The supported options are Rectangle and Ellipse.
    - **Size** – This is the width and height of the model. The size can be buttoned in manually or set from the ROI/Search Area context menu.
- **Search Settings**
    - **Number of Instances** – Defines the number of parts which Part Tracking should expect to find. In order to eliminate finding “ghost” parts, Akrometrix recommends setting this to the exact number of parts in the oven. The max number of instances is 999.
    - **Rotation** – Defines the rotation tolerance for finding a part. This will allow parts to be found which aren’t perfectly aligned with the camera pixels. Akrometrix recommends setting parts up such that they are within 10° of normal to the camera and using as little rotation tolerance as possible. Increasing this value can increase the risk of finding “ghost” parts. The max rotation tolerance is 30°.

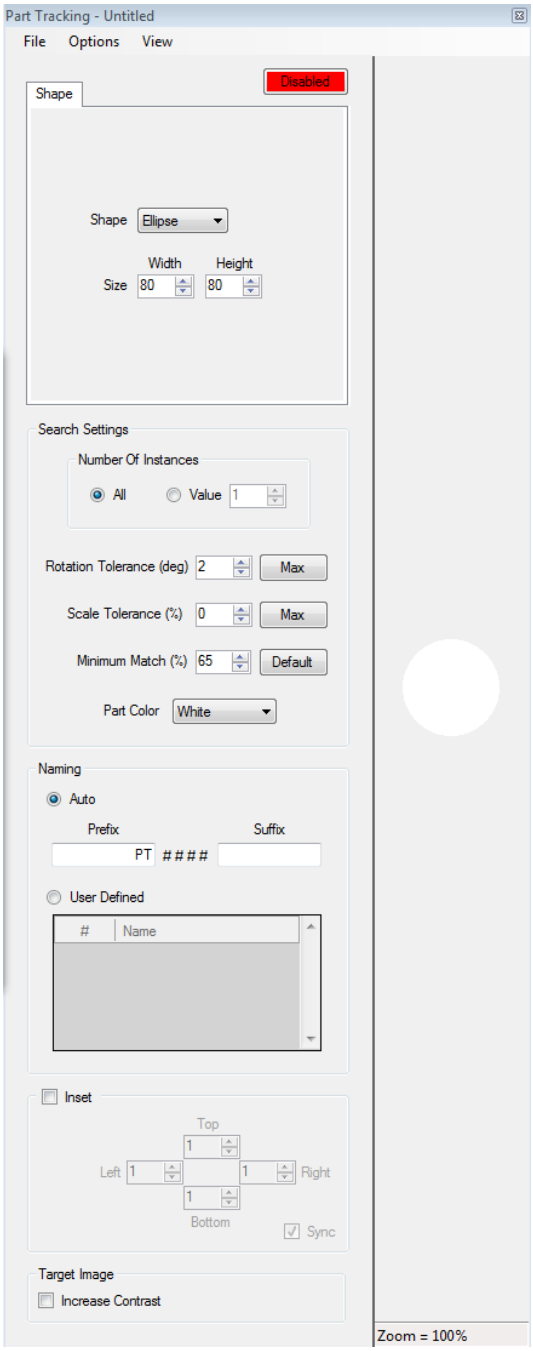

Figure 2.37 Part Tracking control window in Surface Measurement

- **Scale** – Defines the scale tolerance for finding a part. This will allow parts to be found which aren't exactly the same size as the model. This can be useful when comparing results between systems that have ever so slightly different zoom factors. For example, a scale tolerance of 2% on a rectangle model of 168 x 168 pixels will allow Part Tracking to find parts which are anywhere from 165 x 165 to 171 x 171. Increasing this value can increase the risk of finding "ghost" parts.

  - **Minimum Match** – This defines the percentage of edge which Part Tracking has to find to determine that a feature in the camera image is a part. Decreasing this setting will increase the risk of finding “ghost” parts.
  - **Part Color** – Allows part tracking of black (dark) colored parts on a white background. This is mainly for use with samples than cannot be painted.

- **Naming** – This allows the user to set custom ROI names for tracked regions. The default is PTXXXX, starting at PT0001.
  - **Auto** – Allows user to enter custom prefixes and suffixes for ROI names.
  - **User Defined** – Allows the user to set custom names for individual parts. Right click in the gray area to add lines or import a text file of return separated values.
- **Inset (pixels)** – Determines the number of pixels to crop in on found parts. This will effectively reduce the ROI on a part and can be useful for reducing or eliminating edge displacement artifacts. A different inset value can be specified for each side by unchecking the Sync option.
- **Target Image**
  - **Increase Contrast** – Increases the contrast of a surface image before part tracking occurs. This can be useful for finding parts which have low contrast with the oven background.

All of the settings above can be saved in a part tracking file known as *.akx_track. This allows settings to be reused from run to run and site to site without having to manually enter every setting.

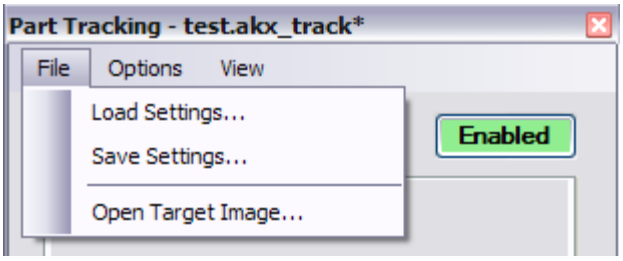

Figure 2.38 Part Tracking File Menu

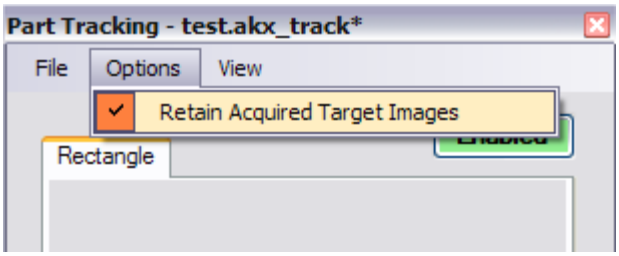

Figure 2.39 Part Tracking Options Window

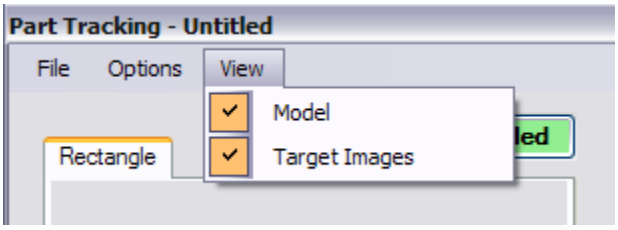

Figure 2.40 Part Tracking View Menu

- **File Menu** – Load and Save *.akx_track files as well as Open previously saved Target Images which can be either *.bmp or *.akx_phase
- **Options** – Allows the user to retain acquired target images in memory so that the part finding options can be experimented with to find the appropriate number and location of parts.
- **View** – Allows the user to show or hide the Model and Target Images display. See the result with both being shown in **Figure 2.41**.

Part tracking can be performed on 'Target Images' which are previously saved phase images of the entire search area. This allows the user to try different part track settings on an input file which is constant. When part tracking is performed on a newly acquired phase image, small changes in image noise can result in varying behavior if the samples have low contrast to their background. Keeping the input phase image constant allows more nuanced testing of different settings without camera noise coming into play.

Note: If Part Tracking is enabled, the Search Area box in the Camera window will affect the search area inside the loaded Target Image(s). If it is disabled, the entire Target Image is searched.

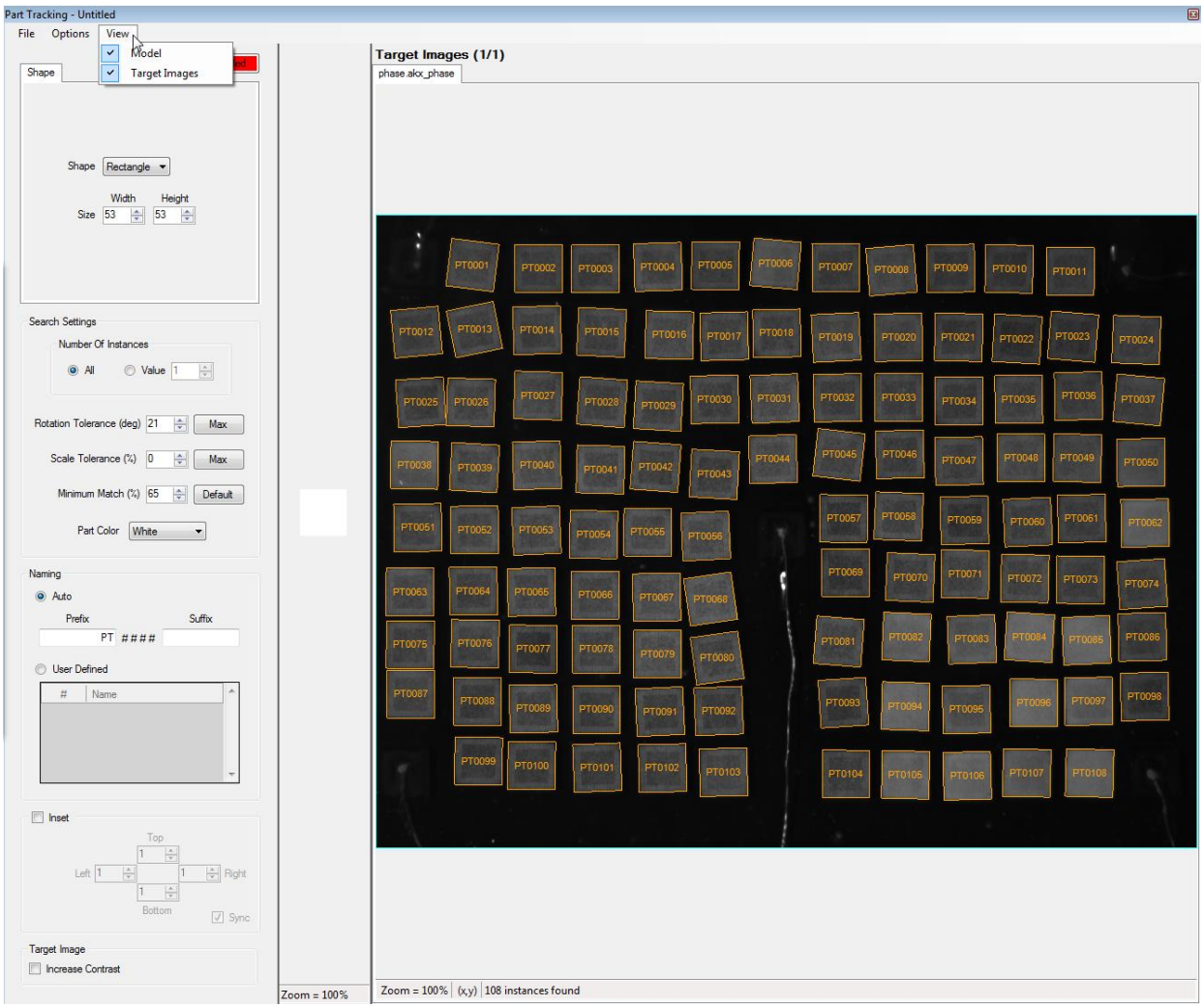

Figure 2.41 Part Tracking window with Target Image

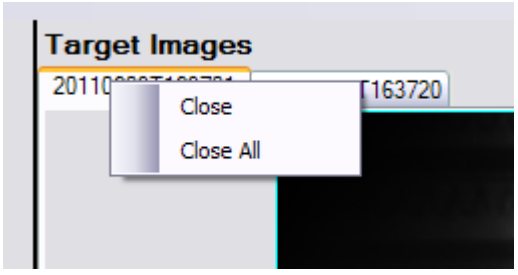

Figure 2.42 Target Image Tab Menu

Figure 2.43 Target Image Context Menu

In the Target Images display section of the Part Tracking window, there are two more right-click context menus available to the user. The user can close tabs using the context menu shown in **Figure 2.42**, as well as search and save Target Images using the menu shown in **Figure 2.43**.

2.11 Part Tracking Quick Guide

1. Enable Part Tracking in either the Part Tracking Window (**Figure 2.37**) or Camera Window context menu (**Figure 2.14**).

2. Align at least one of the parts to be measured such that it is normal (square) to the camera pixel grid.

3. Size the blue, dotted-line ROI such that it contains all parts that will be tracked. Right click inside this ROI and click 'Assign Rectangle Model' (**Figure 2.44**).

4. Size the yellow 'Model' ROI so that it exactly contains one of the parts. Right click on the model ROI and select 'Set rectangle model size' (**Figure 2.45**).

Note: If Shape is set to Ellipse, these options will read 'Assign Ellipse Model' and 'Set ellipse model size'.

5. Choose the desired Part Tracking settings, including # of parts to be found, expected maximum rotation from normal to the camera pixel grid, inset, etc.

Note: Part tracking is compatible with ordinary multi-ROI functionality. Use the commands from **Section 2.5** to add, remove, or edit additional ROIs (**Figure 2.47**).

6. Right click on the camera window and click Acquire (**Figure 2.45**).

Note: Instead of immediate acquisition, which may incur a large processing time with large numbers of parts, the user can check part tracking settings by right-clicking on the camera context window and selecting the 'Track Parts' option shown in **Figure 2.44**. The currently tracked parts will be shown outlined in orange as shown in **Figure 2.46**. The same tracking display will be seen after a normal acquisition with Part Tracking enabled.

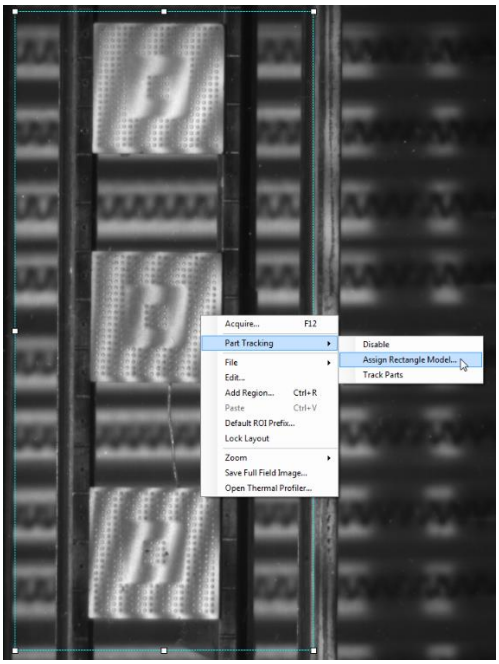

Figure 2.44 Assign Model

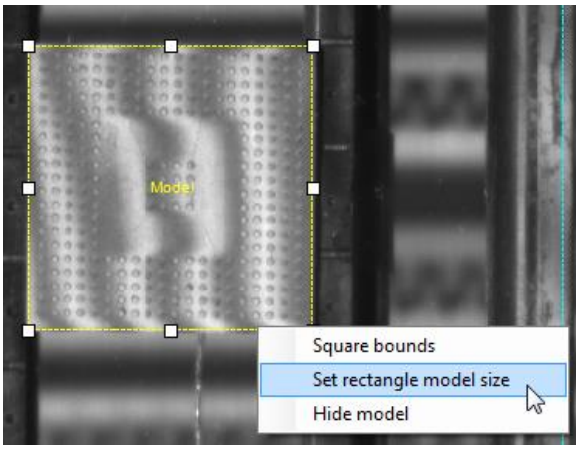

Figure 2.45 Set Model Size

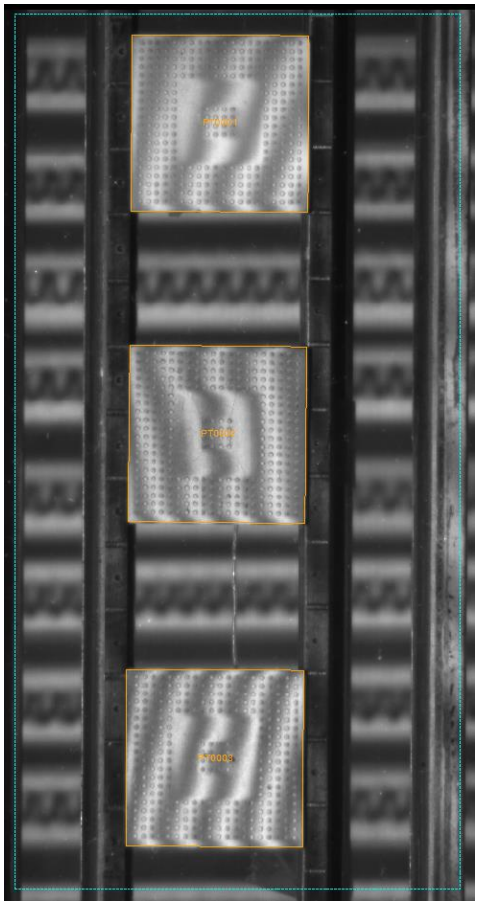

Figure 2.46 Tracked Parts

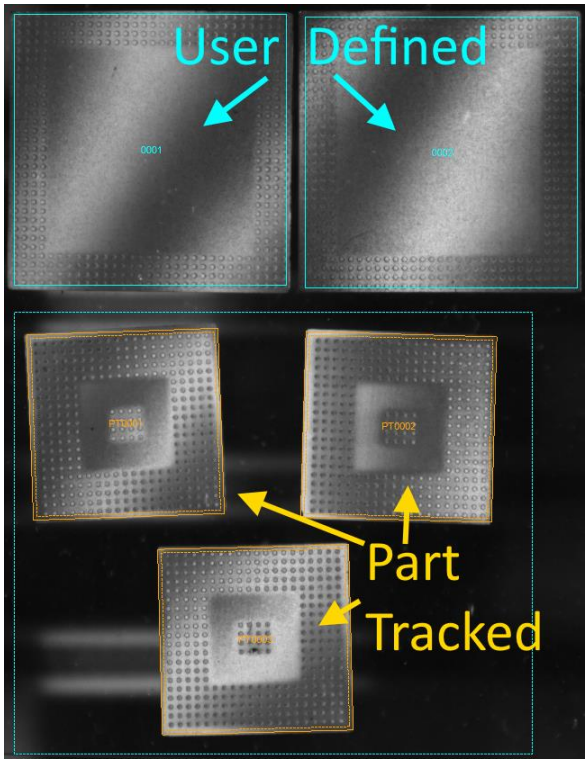

Figure 2.47 Part Tracking and Static ROIs

3 DFP Surface Measurement for AXP

The interface and operation of the **DFP Surface Measurement** program are very similar to the **Surface Measurement** program. A user unfamiliar with the **Surface Measurement** software should read **Section 2** first or refer to it where necessary for operation of the DFP software. In this section, only DFP specific functions will be described.

In the DFP module, a digital projector is software controlled for displaying and phase shifting fringes on the sample surface.

Note: The sample height adjustment stage is still in use. Instead of executing phase shifting, it is used to move the sample vertically for focusing purposes.

3.1 Start-up

1. Remove the TherMoiré grating from the oven lid if it is in place.

2. Install the DFP module. (Refer to the **DFP User Manual**).

3. Run the **DFP Surface Measurement** program by clicking the corresponding button on the Akrometrix Studio Manager toolbar on the left side of the screen. A start-up splash screen appears while the software initializes.

4. When asked whether or not to home the grating stage, ensure that all obstructions are removed from the stage path and press **Yes**. If **No** is pressed, the application will continue to load without homing the sample support motors.

Note: Pressing No will decrease program startup time. In this case, however, absolute sample support position will not be available.

5. The main screen will display and it looks very similar to the normal **Surface Measurement** interface.

3.2 Calibration

Akrometrix believes that calibration should be performed whenever:

- The DFP system is initially installed
- Individual optical components, such as the projector, or video camera have moved

The following procedure assumes that the system has already been aligned according to the DFP User Manual and requires the use of a white painted optical flat (**Figure 3.1**) provided with the system.

1. Place the flat in the system on the normal sample support rails at roughly the middle of the depth of focus.

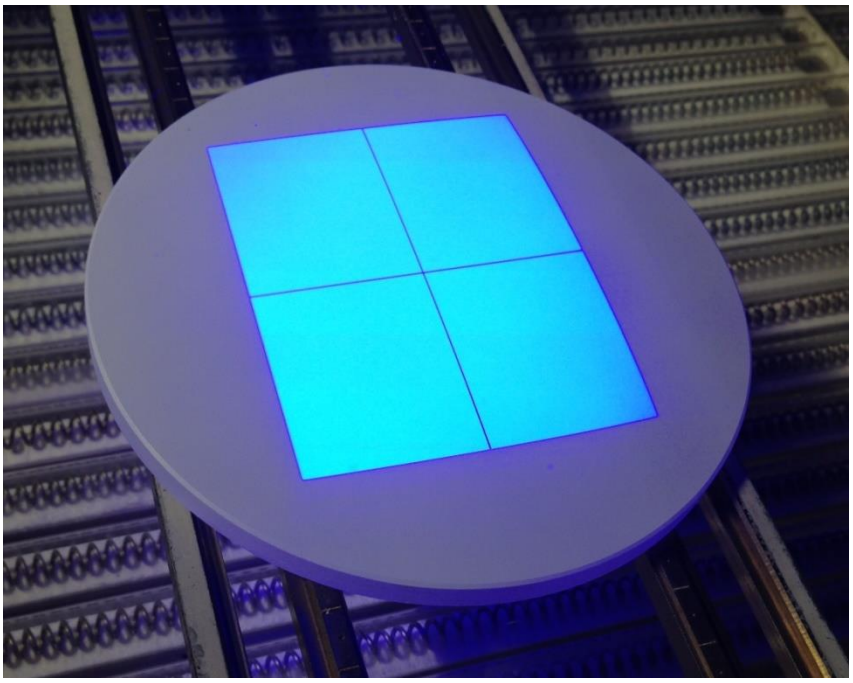

Figure 3.1 White Painted Optical Flat

Note: Avoid touching the top surface of the optical flat. Doing so could leave fingerprints or scratches on the surface and result in measurement errors. Carry the flat by its edges and store it safely when not in use.

2. Jog the flat up or down to ensure that the ends of the vertical line from the projector crosshairs line up with the ends of the software crosshairs as closely as possible. This ensures the block is in the middle of the depth of field. See **Figure 3.2**.

Note: The projector vertical crosshair line may appear somewhat curved; this is a normal consequence of lens distortion and is accounted for in the system calibration.

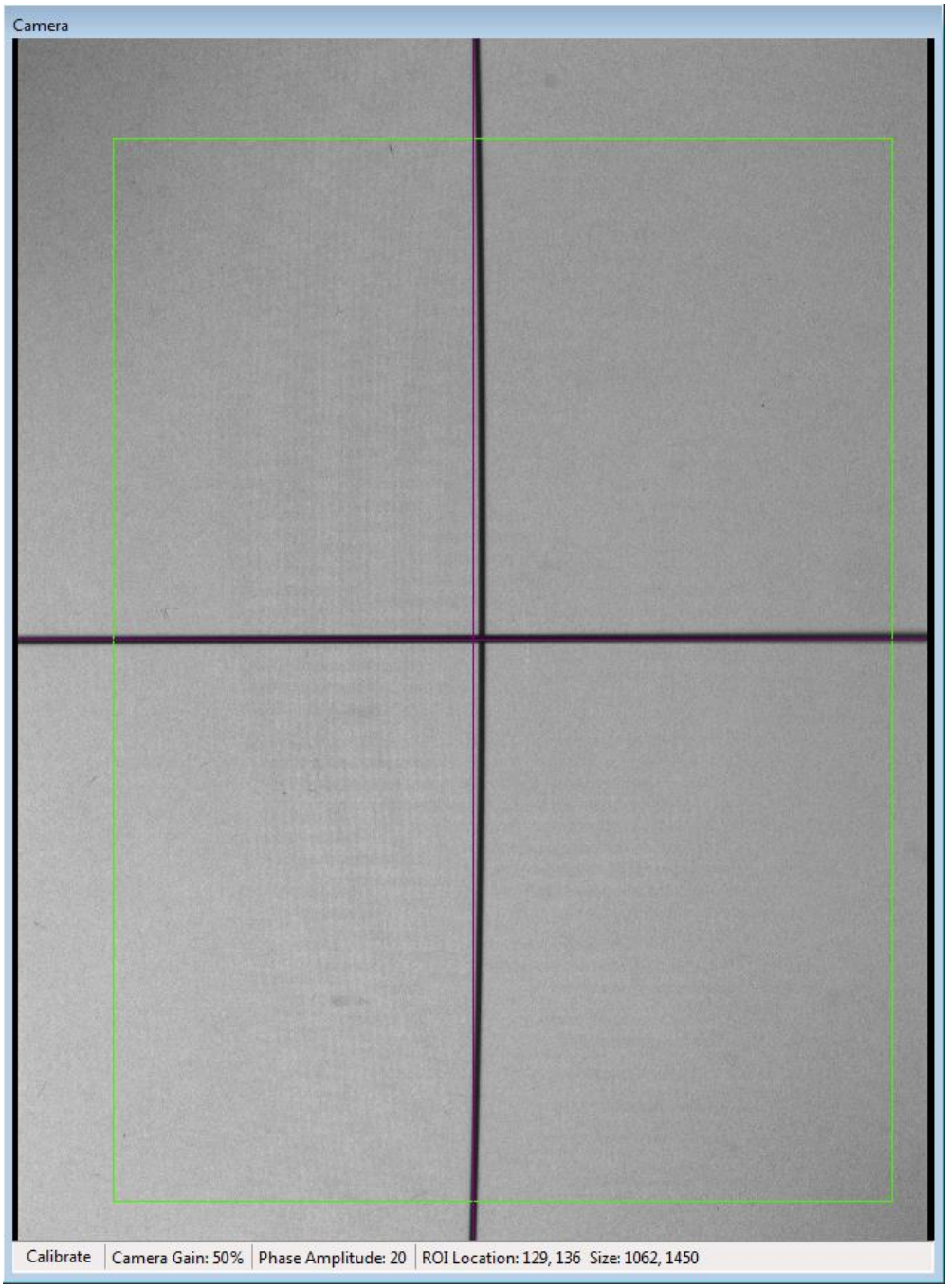

Figure 3.2 Projector and Software Crosshair Alignment

3. Press the Calibrate button on the bottom left of the Camera Window. The system will jog the optical flat down and then back up using the sample support stage. Measurements are taken along the way and a calibration profile including lens distortion is created. A dialog shows calibration progress (**Figure 3.3**). When the calibration is complete a second dialog will confirm if the user wants to accept the new calibration results.

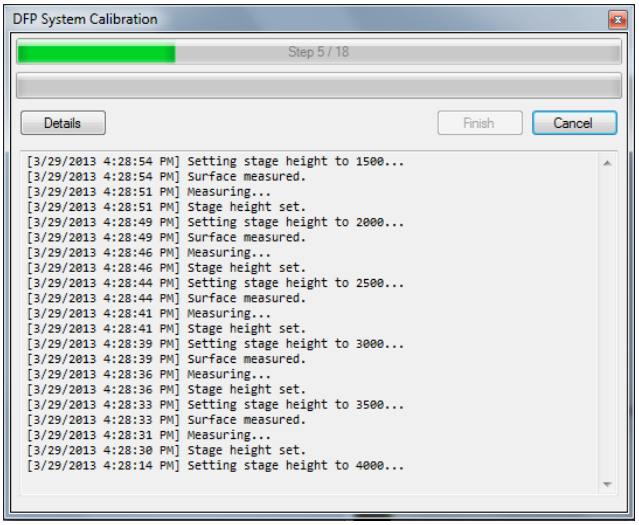

Figure 3.3 Calibration Progress Window

3.3 Accuracy Check

Accuracy checks can be performed on the Akrometrix supplied calibration block by utilizing the step height functionality in **Surface Analysis**. See the **Surface Analysis User Manual** for more information.

3.4 Software Options

DFP Surface Measurement options are the same as in **Section 2.9** with the exception of the Smooth Displacement option which runs a smoothing algorithm on the displacement data. Also, the delay per step and algorithm options are not available here. See **Akrometrix Optical Techniques and Analyses 101** for more details.

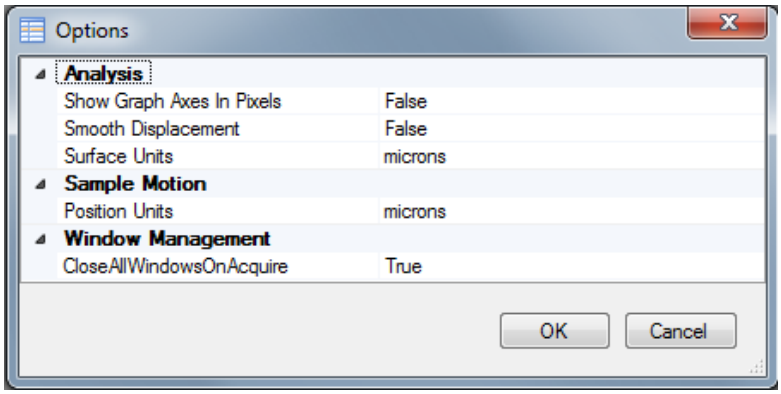

Figure 3.4 DFP Surface Measurement Options

3.5 Software Operation

DFP Surface Measurement and Thermal Profiler work very similarly to the standard versions. The user interacts with the same context menu commands in the Camera window as in **Section 2.4**, with the exception of the Show Crosshairs and Accuracy Check… commands.

4 DIC Surface Measurement

The interface and operation of the DIC Surface Measurement program are very similar to the Surface Measurement program. A user unfamiliar with the Surface Measurement software should read **Section** 2 first or refer to it where necessary for operation of the DIC software. In this section, only DIC specific functions will be described.

Because the DIC technique is fairly different than that of shadow moiré or fringe projection, the program interface is much simpler than for those techniques. No analysis or calibration functions exist in this software. The only major function available is to acquire images from both cameras simultaneously.

Note: The system sample height adjustment stage is still in use. Instead of executing phase shifting, it is used to move the sample vertically for focusing purposes.

4.1 Start-up

1. Remove the TherMoiré grating from the oven lid if it is in place.
2. Install the DIC module. (Refer to the **DIC User Manual**).
3. Run the **DIC Surface Measurement** program by clicking the corresponding button on the Akrometrix Studio Manager toolbar on the left side of the screen. A start-up splash screen appears while the software initializes.
4. When the Homing Sequence Confirmation Dialog is displayed (**Figure 4.1**), press **Yes** to continue program initialization. The TherMoiré sample support stage will home.

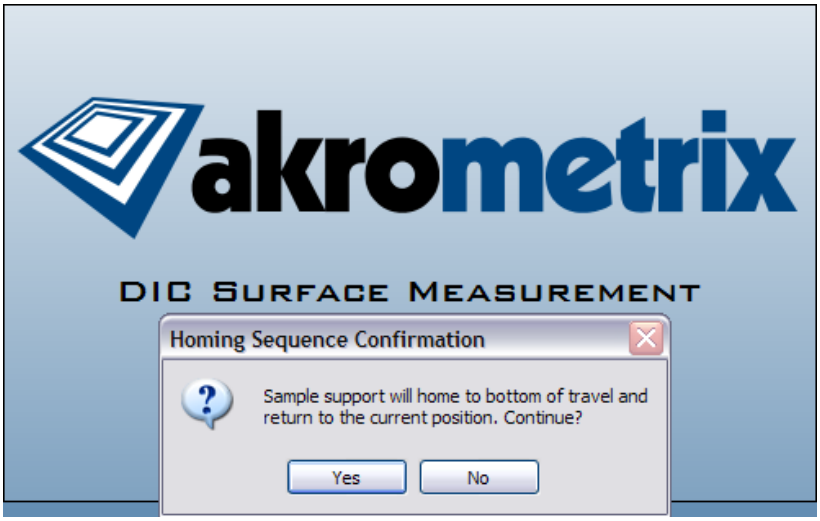

Figure 4.1 Homing Sequence Confirmation

5. The main screen will display and it looks very similar to the normal Surface Measurement interface, except that it has two camera views instead of one (**Figure 4.2**).

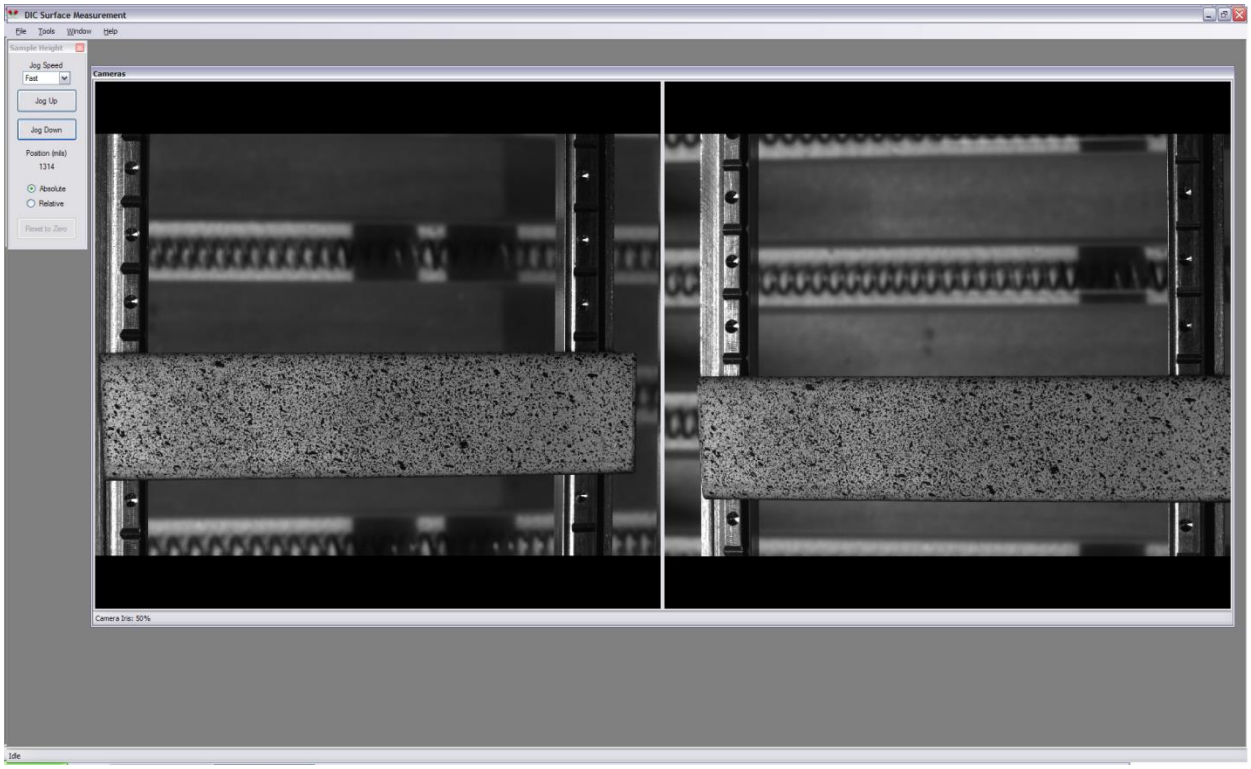

Figure 4.2 DIC Surface Measurement

6. Right-click anywhere in the Camera window to Acquire data or change the camera zoom factor.

4.2 Software Options

A simplified options dialog (see **Figure 4.3**) is available in **Tools→Options**, just as in normal Surface Measurement. There are no new options. The only difference with respect to normal Surface Measurement is that options that do not apply have been removed.

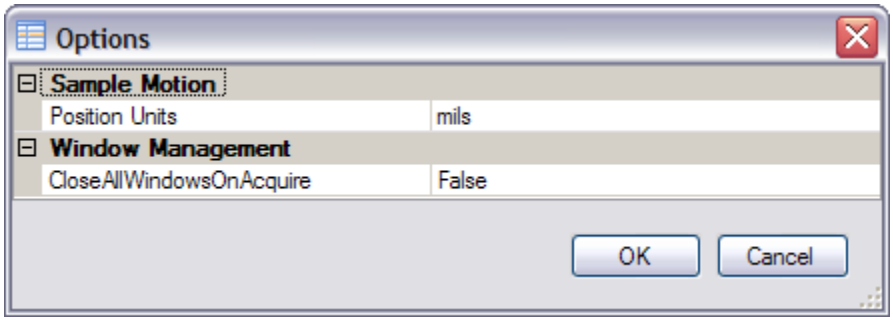

Figure 4.3 DIC Options Dialog

4.3 System Calibration

Calibration of the stereo system requires capturing 15-20 images of a calibration target in different rotations for each image. This is accomplished by the following procedure:

1. Setup the DIC system as described in the DIC User Manual.
2. Position the calibration target underneath the cameras' FOV.
3. Capture an image of the calibration target, then rotate the target. Repeat 15-20 times. The images will pop up, one on top of the other.
4. Save the images into a project folder by using the **File→Save All…** command.

5 Troubleshooting

5.1 Troubleshooting Data Acquisition

As with any measurement system, Akrometrix TherMoiré products have their limitations. These limitations exist because the shadow moiré technique with phase stepping analysis is sensitive to the optical properties of the samples measured. The optical and analytical limitations of the system include:

- Failure to obtain good fringe phase information.
- Loss of resolution on samples with a wide range of reflectivity.

5.1.1 Failure to Obtain Quality Phase Information

Phase information is obtained for each pixel in an image by combining four images on a pixel-by-pixel basis. In general, quality phase information can be obtained anywhere good fringe contrast is observed in the raw video image. Frequently, good phase information can be calculated even where the human eye cannot resolve fringes; for example, against a permanent background pattern such as circuit traces. However, there are situations where quality fringes cannot be obtained:

Symptoms:

- An extremely noisy grayscale signal appears in the phase image. (**Figure 5.1**)
- A banding pattern of grayscale values appears in the phase image.(**Figure 5.2**)
- Discontinuities exist in the calculated displacement data. (**Figure 5.3**)

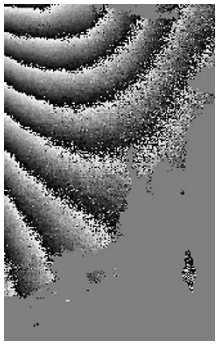

Figure 5.1 Noisy Phase Image

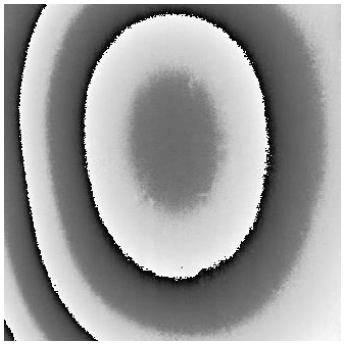

Figure 5.2 Banded Phase Image

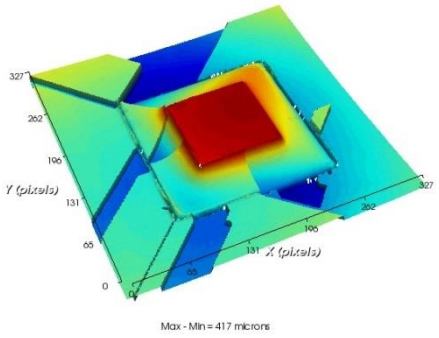

Figure 5.3 Discontinuity Errors in Displacement Data

Cause: Discontinuous Sample

Fringes are not generated at holes and cutouts or where the sample surface is shadowed by components or other obstructions; fringes can only appear on the sample surface itself. While these are obvious statements, the problems resulting from nonsense phase calculations within such localized regions frequently cause incorrect interpretation of the phase image.

Surfaces with abrupt discontinuities, such as steps, components, or solder balls, can create analysis errors characterized by sharp diagonal edges in the calculated

displacement surface (**Figure 5.3**). For shadow moiré, abrupt implies adjacent pixels with a height difference greater than half the fringe value, e.g. greater than 0.005” (0.127 mm) for a 100 line per inch grating or 0.0017” (0.043 mm) for a 300 lpi grating.

Solution:

a. Use the Phase Amplitude option with an appropriate threshold value to automatically eliminate bad pixels from the phase image.

b. Use a grating with a larger pitch, e.g. a 100 lpi grating instead of a 300 lpi.

c. Apply a user-defined mask over holes and slots using Surface Analysis. See the Surface Analysis User Manual for more details.

d. Within the Surface Analysis program, vary the filter conditions.

Cause: Incorrect Phase Step Distance

An incorrectly assigned phase step size results in the incorrect calculation of phases. This is due to incorrect software grating selection, incorrect calibration values, or physical contact between the sample and the grating. If the sample support frame is raised so that the sample is touching the grating, the sample is not uniformly translated relative to the grating during the phase stepping data acquisition.

The grating is touching the sample (more generally, some point on the lid is touching some point on the sample support fixture), so that the grating does not translate independently of the sample during phase stepping. The phase image frequently has the appearance of **Figure 5.2**. Use the Sample/Grating Height adjustment dialog to manually raise and lower the sample at Slow Speed. If the sample is touching, the fringe pattern is frozen at some or all points on the sample.

Solution:

a. Lower the sample, or raise the grating, so that they are not touching.

b. Check to make sure the correct grating is selected from the drop down list in the software.

c. Open the calibration file and check that the grating value is within ±10% of the theoretical value. If not, perform calibration.

Cause: Sample-Grating Distance

A fringe pattern is not visible when the distance between the sample surface and the grating is too large. There is an effective working distance below the grating within which fringes on the sample surface can be observed. The shadow of the grating loses sharpness as the distance from the grating increases due to diffraction effects and finite thickness of the light source. As a rule of thumb, these distances are approximately:

- 0.8 in (20 mm) for the 50 lpi grating
- 0.2 in (5 mm) for the 100 lpi grating, and
- 0.02 in (0.5 mm) for the 300 lpi grating.

Solution:

Adjust the height of the sample, either with the servomotor stages or by changing the sample support fixture. Position the sample so that it shows a high contrast fringe pattern on the raw video feed, but is not touching. If the sample is translated from this point using the servomotor stages, the user observes that the fringe pattern moves smoothly and uniformly across the sample. If some part of the fringe pattern does not move during translation, this usually indicates that that part of the sample is touching the grating.

In some cases, it may not be possible to bring the sample surface within working distance of the grating, e.g. with a tall component or connector on the sample surface. Approaches Akrometrix has used under these circumstances include:

- Inverting the sample and measuring the back surface, or
- Using a lower resolution grating with a larger working distance.

Cause: Unfavorable Surface Optical Properties

The surface has unfavorable optical properties. Shadow moiré is based on diffuse reflection from the sample surface, which allows the interference patterns between the shadow grating and the reference grating to be observed. Surfaces that provide poor diffuse reflection include:

- transparent surfaces, such as glass
- specular reflecting surfaces, such as polished metal or solder pads
- black or other dark-colored surfaces

Solution:

a. Using the Phase Amplitude option with an appropriate threshold value automatically masks regions with such unfavorable optical properties, excluding these bad pixels from the phase image and subsequently the analysis calculation.

b. Painting the sample with a thin coat of high temperature white paint provides optimal surface properties for shadow moiré without significantly affecting mechanical properties. Other surface treatment methods may be used, depending on the sample, including creating a matte finish on a metal surface by etching or abrasion.

c. Blurring the focus of the camera can help in some circumstances. For example, blurring allows a strong fringe signal from the terminal ring around a through-hole to combine with the weak fringe signal from adjacent regions of solder mask. This technique does reduce the lateral resolution of the measurement.

Cause: Stray Sample Illumination

Illumination of the sample by any light other than the linear fiber optic light source decreases the shadow contrast. In addition to ambient light, frequent sources of additional light are reflections inside the sample chamber and light from the infrared heating source.

Solution:

a. Close system doors & turn off room lights.

b. Shield off as much of the heater light as possible by laying black paper or cloth shields on top of the oven window.

c. Make sure that the IR filter is in place on the camera lens. In extreme cases, shield off as much of the heater light as possible by laying black metal, paper or cloth shields on top of the oven window.

5.1.2 Additional Sources of Error

Several second-order effects have been observed in phase-stepped shadow moiré measurements that can affect results, particularly for extremely small and/or flat samples. Periodic structures in the apparatus or samples can introduce corresponding periodic errors in the phase image. In addition, the phase calculation algorithms inside Akrometrix software can introduce small periodic errors.

High magnification of the sample can cause the grating lines themselves to be resolved, which can cause a periodic error in the phase calculation. Choose a combination of magnification and grating frequency so that the lateral resolution is at least one full grating pitch. The general guidelines below minimize this problem:

1. If the full field of view of the video image is less than 160 mm in width, use a 100 lpi or higher grating.

2. If the full field of view of the video image is less than 60 mm in width, use a 300 lpi or higher grating.

Even when these guidelines are used, interference between camera pixel spacing and grating line spacing can produce aliasing in the video image. This initially appears as low contrast vertical (or near vertical) fringes across the image that vary in pitch and rotation as the zoom lens magnification is varied. This effect can be minimized by varying the lens magnification.

Interference between a periodic structure on the sample surface (e.g. a field of solder pads on a BGA substrate) and the grating line spacing can introduce a periodic phase calculation error. This effect can generally be observed by eye in the live video image of the sample and may be eliminated by re-orienting the sample or changing the grating (e.g. from 100 lpi to 300 lpi).

A second problem related not to system hardware, but to system software is caused by the breakdown of the sinusoidal approximation used in the phase calculation (see **Akrometrix Techniques and Analysis 101**). This appears as a series of ripples superimposed on the final displacement results. The ripples are characteristically parallel to the fringes appearing in the shadow moiré fringe pattern, but at four times the fringe frequency (a similar effect occurs when an incorrect step height is used, but the frequency of ripples is two times the fringe frequency).

In general, the amplitude of the ripples is comparable to the resolution of the system and the effect on accuracy is within the system specification. However, saturation of the video camera by regions of high reflectivity can enhance this effect to higher levels. If observed, this effect may be reduced through elimination of camera saturation by closing the lens iris or reducing light source power. In some cases, the effect may also be reduced

by slightly increasing the distance between sample and grating. Consult with Akrometrix technical support if this effect is creating significant measurement problems.

5.1.3 Loss of Contrast and Resolution

A more subtle concern in making phase-stepped shadow moiré measurements deals with the relationship between the digital resolution of the intensity measurements and the precision of the vertical displacement data. The high resolution of the phase stepping method is based on the number of grayscale levels available when the fringe pattern is digitized. Using a 12-bit digitizer (new as of Studio 8.0), there are 4,096 grayscale levels to encompass the fringe pattern from its brightest to darkest pixel. These 4,096 levels directly relate to the claim that vertical height measurement resolution is 100 times better than the grating pitch. If there are fewer levels available for digitization, the measurement resolution is proportionately reduced.

The manual lens iris should be adjusted so that maximum sample brightness is just below the saturation level of the digitizer. This is generally sufficient when the illumination and diffuse reflectivity of the surface is uniform across the sample. However, when the sample contains regions of high and low reflectivity, the fringe intensity signals from the two regions each cover only a small amplitude at the extreme high and low ends of the digitization range. In order to encompass both the dark fringe pixels in the low reflectivity region and the bright fringe pixels in the high reflectivity regions, each of the two signals spans a smaller range of digitization levels and the vertical displacement resolution in each region is reduced.

Painting the surface is the simplest procedure to eliminate this problem. If the surface cannot be painted, useful phase and displacement information can still be obtained for many samples, but the resulting loss of precision should be kept in mind.

Appendix A - Miscellaneous Information

A.1 File Formats

Akrometrix Surface Measurement saves data in a format with extension *.akx_phase or *.akx_disp. These files should automatically be associated and can only be opened with the Surface Analysis application. Other image file formats can be exported from the program but cannot be loaded back into any Akrometrix software. Image export formats include: *.png, and *_ph.tif. Lastly, recipe files are saved and loaded in the *.akx_recipe format.

A.1.1 Metadata Fields

Metadata fields embedded in *.akx_phase or *.akx_disp objects can be used in building filenames, output paths, and report labels in various places in Akrometrix Studio applications. Some of the more commonly used metadata fields are described below.

<RoiName>	User defined when adding ROIs to the Camera Window. Also defined when partitioning in Surface Analysis.
<LotId>	User defined in the Metadata window (**Error! Reference source not ound.**)
<TestId>	User defined in the Metadata window (**Error! Reference source not ound.**)
<OperatorId>	User defined in the Metadata window (**Error! Reference source not ound.**)
<ProductId>	User defined in the Metadata window (**Error! Reference source not ound.**)
<TemperatureNominal>	User defined when creating a profile in **Profiler Generator**
<TemperatureReading>	Any thermocouple data for the acquisition (can include up to 16 temperatures in the case of a CRE measurement). With no suffix, this metadata tag will provide TC1 data, but a two digit numerical suffix, such as “02” will provide the data for the corresponding thermocouple.
<TemperatureSetpoint>	User defined when creating a profile in **Profile Generator**

Other metadata fields such as Pin 1 Location, Equipment Model, etc. are available by right clicking on any phase or displacement image and going to **Properties…**. Any entry in this list can be surrounded by “<” “>” symbols to indicate to the application to use that metadata field in populating the corresponding text entry area. In addition, any gauge value can be added in the same way.

A.2 Keyboard Shortcuts

F3	Toggle Fill ROI behavior
F5	Bring Camera Window to foreground (will not hide Camera Window)
F6	Show/Hide Sample Height Window
F7	Show/Hide Camera Control Window
F12	Perform an Acquire (capture data)

Ctrl+R	Add new ROI
Ctrl+V	Paste copied ROI
Ctrl+T	Open Thermal Profiler application
Ctrl+S	Save as *.akx_*
Ctrl+I	Save as image
Ctrl+W	Close
Ctrl+O	Open in Surface Analysis
While the ROI has focus the following keyboard shortcuts apply:	
Ctrl+5	make ROI its maximum size.
Alt+5	make ROI half of maximum size and position in center of field of view.
Ctrl+C	Copy size, shape, and location of selected ROI
Up Arrow or 8 on NumPad	Move ROI up one pixel
Down Arrow or 2 on NumPad	Move ROI down one pixel
Left Arrow or 4 on NumPad	Move ROI left one pixel
Right Arrow or 6 on NumPad	Move ROI right one pixel
1 on NumPad	Move ROI down one pixel and left one pixel
3 on NumPad	Move ROI down one pixel and right one pixel
7 on NumPad	Move ROI up one pixel and left one pixel
9 on NumPad	Move ROI up one pixel and right one pixel
Ctrl plus any of the above will increase the ROI size in the desired direction.	
Alt plus any of the above will decrease the ROI size in the desired direction.	