SmartVIS

SmartWLI

# smartVIS3D

# Software User Guide

Gesellschaft für Bild- und Signalverarbeitung (GBS) mbH

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smartVIS3D® Software User Guide for Microsoft Windows® Operating System.

# Customer Service

If a problem arises which cannot be resolved with the help of this documentation, please contact customer service using any of the following numbers or addresses:

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# Maintenance and Warranty

Any type of software maintenance, including applying of software updates and bug fixes, will be performed by the manufacturer using remote maintenance software where possible.

The length of the warranty for the purchased smartVIS3D software is governed by the concluded contract with Gesellschaft für Bild- und Signalverarbeitung mbH.

# Content

# 1. Measurement principle

## 1.1. Principle Description

The basic white-light interferometry setup utilizes an optical interferometer, e.g. Michelson interferometer as shown in Figure 1. The principle behind the measurement process is based upon the fact that spatially and temporally coherent light waves can be superimposed. To exploit this behavior, the optical interferometer is equipped with a broadband white-light source and the following steps are applied during the measurement procedure. The light source emits a beam into the beam splitter, where it is splitted into two separated beams. One of these created beams (reference beam) follows a constant optical path to the reference mirror and the other one (measurement beam) is passed to the object to be measured. Both beams are reflected from corresponding surfaces and directed through the beam splitter to a CCD-camera (cf. Figure 1). On the way back the reflected beams are superimposed. If the optical path difference of both beams is within coherence length of used light then interferences occur.

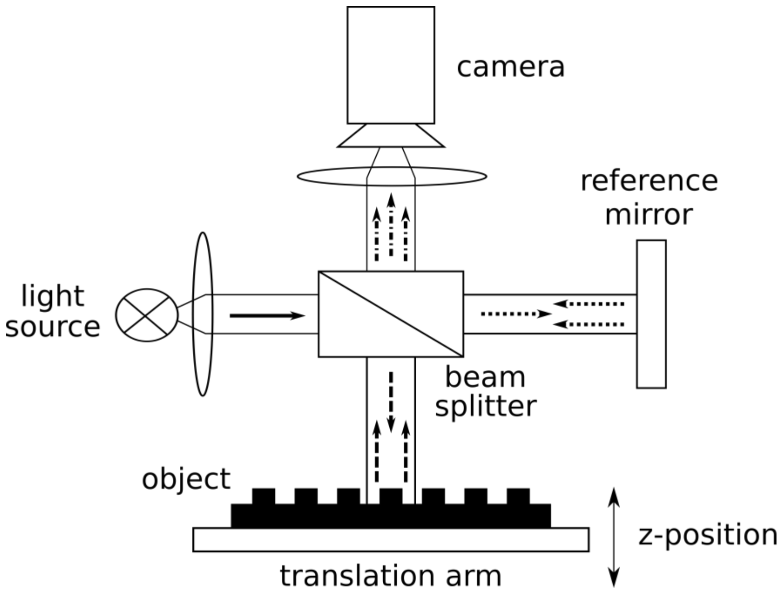


FIGURE 1: MICHELSON'S INTERFEROMETER AND THE WORKING PRINCIPLE OF THE WHITE-LIGHT INTERFEROMETRY

During the measurement procedure the objective is moved within a defined range (the upper and lower limits of which can be set in the control software) perpendicularly to the specimen's surface using a specific step pattern, the default step width in the smartVIS3D measurement software from GBS mbH is λ/8. Due to this translation of the objective the path length of the measurement beam is altered, while the path length of the reference beam remains the same. Therefore a change of interference intensities recorded by the camera sensor can be observed. When the optical path difference is zero for a particular x,y-position on object's surface, then the interference intensity for this position is maximal. The z-position of the translation arm at which the maximum interference was measured can be used to compute the height for that specific x,y-location. In Figure 2 during a scan procedure with N measurement positions in z-direction obtained interference signals (interferogram) for adjacent pixels are shown.

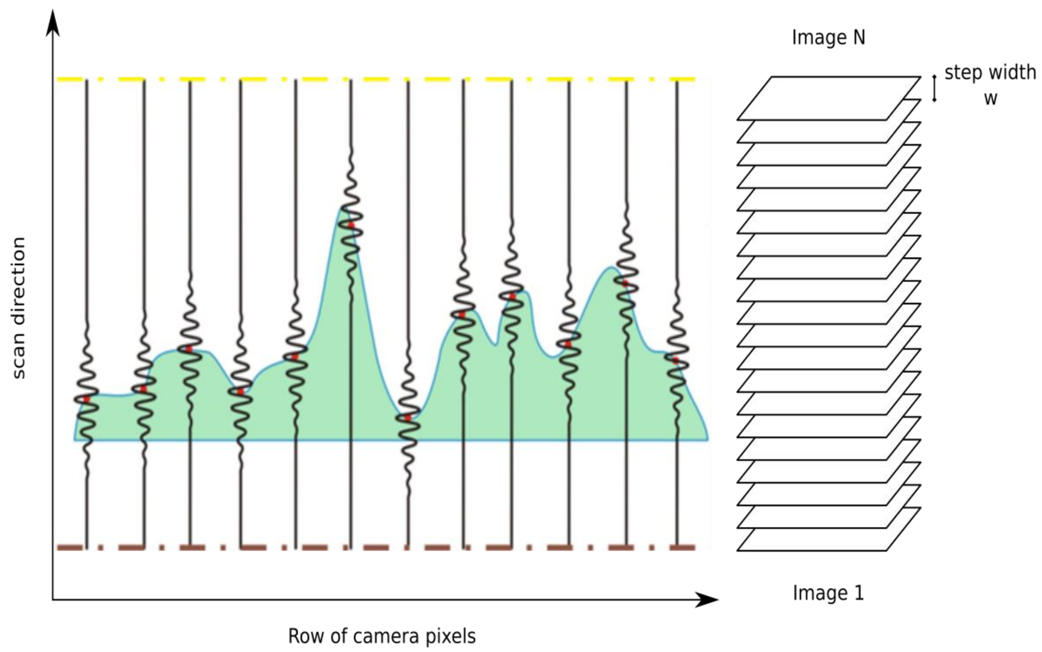


FIGURE 2: DURING THE MEASUREMENT PROCEDURE OBTAINED INTERFEROGRAMS FOR ADJACENT PIXELS. THE RED CIRCLES REPRESENT THE SCAN POSITION (IN Z-DIRECTION) AT WHICH THE MAXIMUM INTERFERENCE INTENSITY FOR A PARTICULAR PIXEL WAS MEASURED

In Figure 2 it can be also seen, that the signal segments of obtained interferograms at which significant interference intensities can be observed are much smaller than the scan range (N * w) of the measurement procedure. These segments are called correlograms and they correspond to the coherence length of the used white-light source.

After the measurement has been completed smartVIS3D transmits the measurement results to the MountainsMap® analysis software.

## 1.2. Vertical Scanning-Interferometry (VSI) and Phase-Shifting Interferometry (PSI) Modes Description

In the following table the comparison of the supported measurement modes VSI and PSI in smartVIS3D software is shown.

| Mode | VSI | PSI |
|---|---|---|
| **Light-source and filter settings** | • white-light with short coherence length<br>• no filter | • white-light with long coherence length<br>• bandpass filter |
| **Properties** | • non-tactile and non-destructive<br>• fast (seconds to few minutes)<br>• height resolution of ≤10 nm<br>• operates on rough surfaces with an $R_a$ < 400 µm | • non-tactile and non-destructive<br>• very fast (few seconds)<br>• height resolution of ≤1 nm<br>• operates on smooth, polished surfaces with an $R_a$ < 200 nm |
| **Description** | Because white light – due to its broad spectrum – exhibits a very short coherence length, interference fringes are observed only in a small band around the focus position. The interference fringe contrast maximum is achieved when passing through the focal distance. When the objective scan position adjuster moves the objective through the previously set movement range, individual images are acquired at specific step distances (the default is λ/8). The total number of individual images increases as the interval size increases.<br><br>Example: If λ/8 = 79 nm and the interval size is set to 200 µm, a total | Generates phase data from the intensity signals which is then used to calculate the surface profile. The objective is held at its focal distance. The interference maximum (of the correlogram) completely fills the image. The interference objective is moved and 5 individual images are taken. Between each of these 5 scan positions a phase-shift of λ/8 is used. If the height difference between adjacent measurement points on the clean surface is larger than λ/4, then the height deviation can be a multiple of λ/2 and the wavefront cannot be reliably reconstructed. Because of this ambiguity, normal phase-shifting interferometry (PSI) can |

| | | |
|---|---|---|
| | number of approx. 2500 individual images (the image stack) will be taken. All of these ~2500 images must be processed by the measurement software. | only be used for scans of very smooth continuous surfaces. |

# 2. Software Description

The user interface of the smartVIS3D measurement software features a clearly arranged and easy-to-use layout. The measurement software in combination with the MountainsMap® analysis software is delivered pre-installed and ready to use.

## 2.1. Main Window

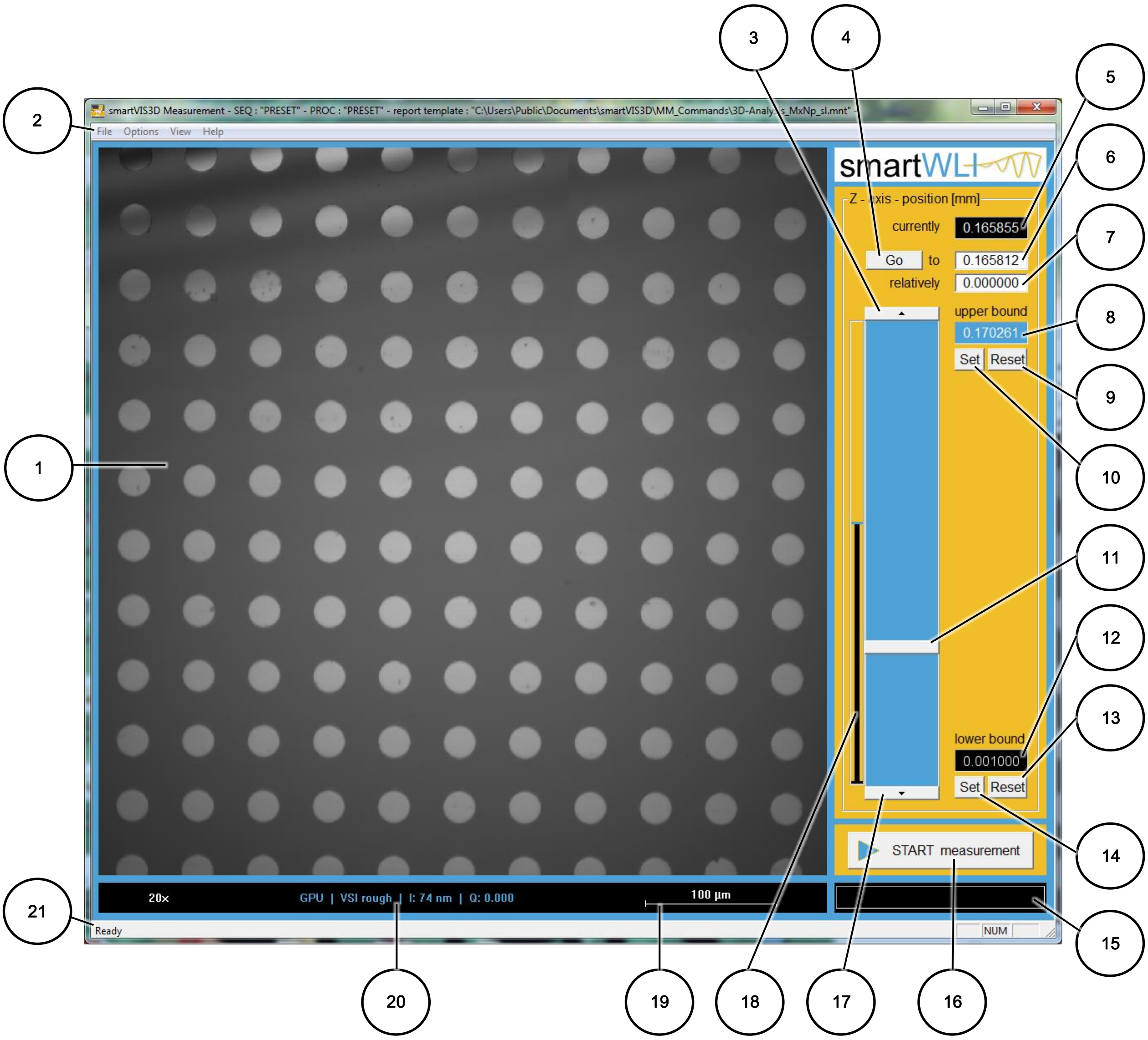


FIGURE 3: SMARTVIS3D MAIN WINDOW

| No. | Description |
|---|---|
| 1 | Live image captured by the camera. The live image corresponds to the measurement field. The magnification factor, e.g. 20x, of the objective is shown on the left side below the image. The length scale, e.g. 100 µm, is shown on the right side below the image. |
| 2 | Menu items (File, Options, View, Help). |
| 3 | Scroll-up button for z-positioning of the objective using the piezo objective adjuster. The positioning button is controllable by mouse. |
| 4 | “Go” button to move the z-position scrollbar (11) to the z-position defined in field (6) or to a position with relative distance defined in field (7) from the current position shown in field (5). |
| 5 | Display field for the current z-position of the objective. |
| 6 | Input field for setting the desired z-position to which the scrollbar (11) will be moved when the “Go” button or the Enter key on the keyboard is pressed. Additionally after pressing the “Go” button or the Enter key the current z-position value in field (5) will be updated to the value provided here. |
| 7 | Input field for setting the desired z-position relatively to the current z-position. After pressing the “Go” button or the Enter key on the keyboard the z-position scrollbar (11) will be moved from the current position by the value provided here. Additionally after pressing the “Go” button or the Enter key the current z-position value in field (5) will be updated to the new position value. |
| 8 | The display field shows the **maximum** z-position (background color of the field is black) or user-defined **upper** limit on z-position (background color of the field is blue). |
| 9 | By the user defined **upper** limit on z-position shown in display field (8) can be resetted to the **maximum** z-position value by pressing this button. |

| | |
|---|---|
| 10 | The **upper** bound z-position shown in display field (8) can be set to the current position of the scrollbar (11) using this button. |
| 11 | Z-Position scrollbar, which can be used to manually set the z-position of the piezo adjuster and to select the z-position for the maximum and minimum scan position. Each time the position of the scrollbar is changed the value in display field (5) is updated to the new position and in the live view (1) interference patterns resulting from the new z-position of the piezo adjuster can be seen. The scrollbar is controllable by the mouse. |
| 12 | The display field shows the **minimum** z-position (background color of the field is black) or user-defined **lower** limit on z-position (background color of the field is blue). |
| 13 | By the user defined **lower** limit on z-position shown in display field (12) can be resetted to the **minimum** z-position value by pressing this button. |
| 14 | The **lower** bound z-position shown in display field (12) can be set to the current position of the scrollbar (11) using this button. |
| 15 | Progress bar for the measurement process. |
| 16 | The “Start Measurement” button starts the measurement. It is enabled after the user has set the **upper** and **lower** limit for the scan procedure. |
| 17 | Scroll-down button for z-positioning of the objective using the piezo objective adjuster. The positioning button is controllable by mouse. |
| 18 | The positioning/measurement range bar shows the currently specified position (blue end marker, top) and the user-defined scan interval (black) with respect to the entire available scan range. |
| 19 | Measurement scale display (length scale). |

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|---|---|
| **20** | Measurement options (section 2.3.1):<br>• Processing unit (CPU / GPU)<br>• Measurement Method (VSI / PSI)<br>• Scan step width in nm<br>• Measurement data quality threshold |
| **21** | Current status. |

## 2.2. File Menu

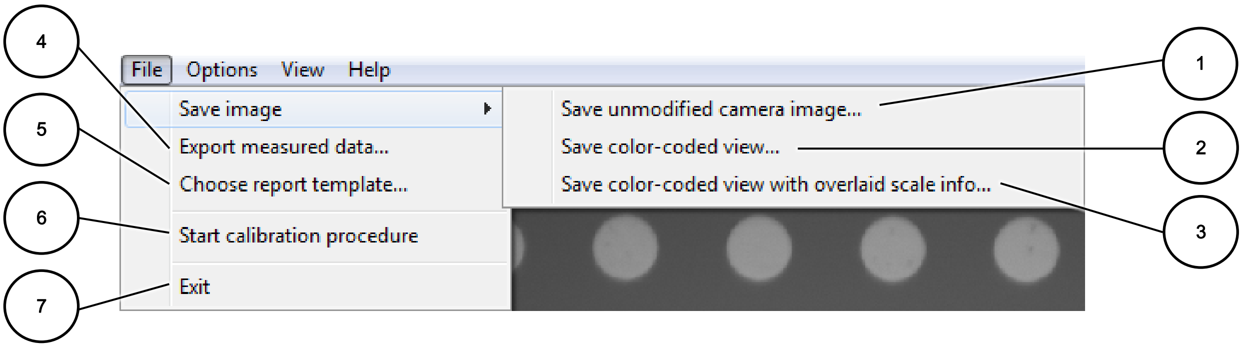
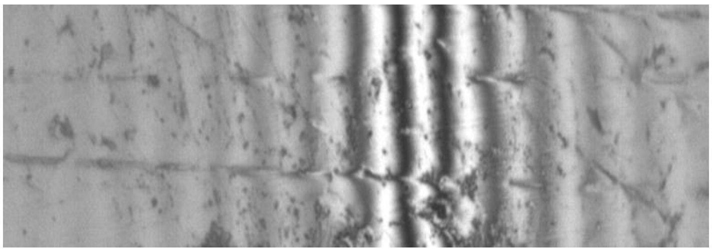
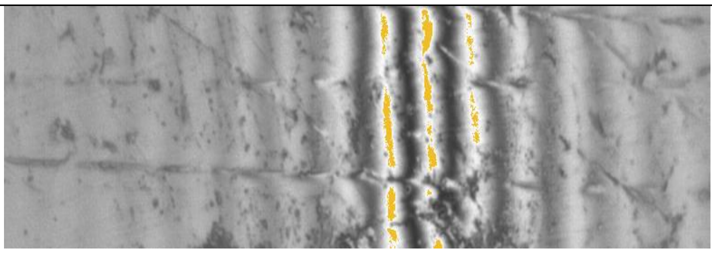
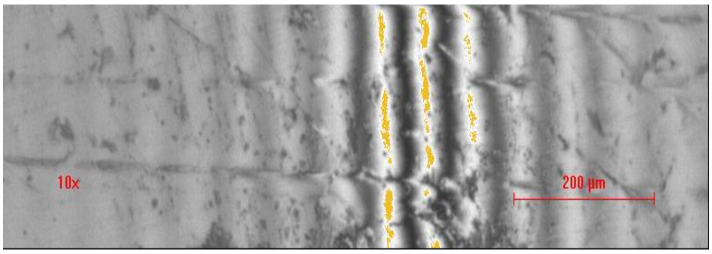
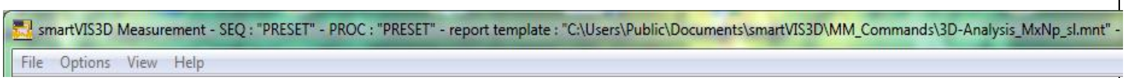



FIGURE 4: SMARTVIS3D FILE MENU

| No. | Description |
|---|---|
| **1** | Saves the currently displayed camera image available in the data processing format (monochrome, 16-bit) as an image file: (*.tif), (*.bmp), (*.jpg) or (*.hdr), like shown in the following figure:<br> |
| **2** | Saves the current color-coded view of the camera image (color, 8-bit, with pseudo-colors for under- or overexposure as an image file: (*.tif), (*.bmp), (*.jpg) or (*.hdr), like shown in the following figure: |

| | |
|---|---|
| |  |
| 3 | Saves the current color-coded view of the camera image with additional information (displayed in red) as an image file: (*.tif), (*.bmp), (*.jpg) or (*.hdr), like shown in the following figure:   |
| 4 | Opens a file dialog which can be used to export the measurement results into the following formats:<br>• MountainsMap® binary file format: *.sur<br>• SPIP binary file format: *.bcrf<br>• SPIP ASCII file format: *.asc<br>• Pointwork ASCII file format: *.a3d |
| 5 | Opens a file dialog to choose a MountainsMap® document template: *.mnt. The name of the selected template will then appear in the title area of the main window (smartVIS3D measurement - chosen report template: “selected name”.mnt), like shown in the following figure:   |
| 6 | Starts the calibration procedure. |
| 7 | Exits the smartVIS3D measurement software. |

## 2.3. Options Menu

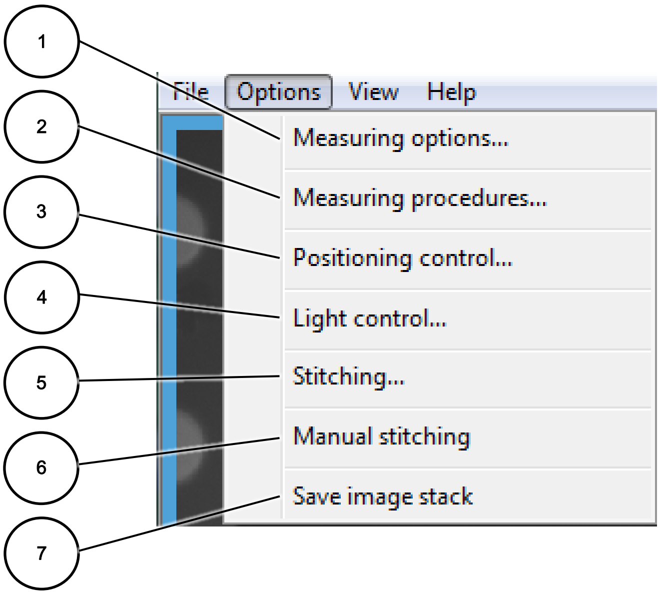



FIGURE 5: SMARTVIS3D OPTIONS MENU

| No. | Description |
|---|---|
| 1 | Opens the “Measuring options” dialog, see section 2.3.1. |
| 2 | Opens the “Measuring procedures” dialog, see section 2.3.2. |
| 3 | Opens the “Positioning device motion control” dialog, see section 2.3.3.<br><br>Note: “Positioning control” menu entry is available only for devices with motorized positioning axes. |
| 4 | Opens the “Light control” dialog, see section 2.3.4.<br><br>Note: “Light control” menu entry is available only for devices with an integrated light control hardware module. |
| 5 | Opens the “Stitching-Measurement” dialog for the auto-stitching process, see section 2.3.5.1.<br>For general information on the stitching process refer to section 2.3.5.<br><br>Note: “Stitching” menu entry is available only for devices with motorized positioning axes. |

| | |
|---|---|
| 6 | Shows reference lines for the manual stitching process, see section 2.3.5.2. For general information on the stitching process refer to section 2.3.5. |
| 7 | "Save image stack" is an option field which can be checked and unchecked. On startup of the smartVIS3D software this field is unchecked. By checking this option field, using the left mouse button, the control logic of the software will be notified that all captured interference images (image stack) must be stored on the hard drive. This image stack can be used by the manufacturer to perform debugging and analysis steps in case measurement or analysis errors are encountered during a scan procedure. |

## 2.3.1. Measuring Options Dialog

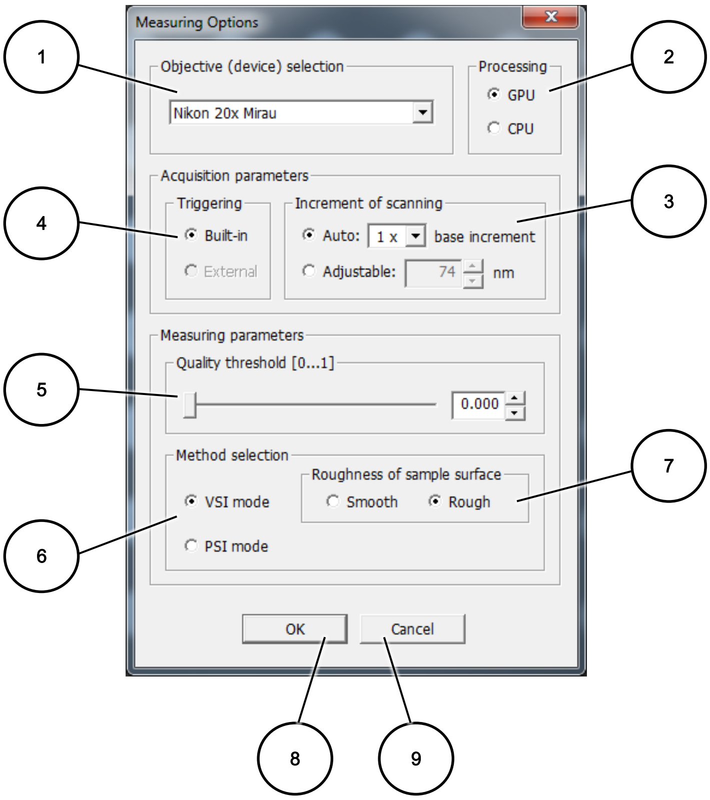
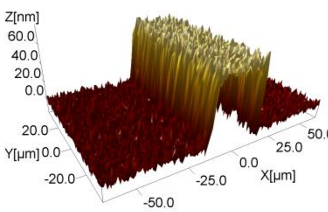


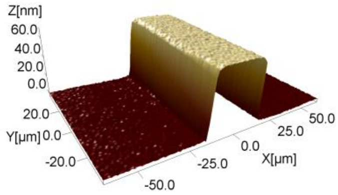

FIGURE 6: SMARTVIS3D MEASURING OPTIONS DIALOG

| No. | Description |
|---|---|
| 1 | Currently selected objective. Make sure to select the objective corresponding to the mounted objective, as the measurement accuracy depends on it. |
| 2 | Selection of the processing unit:<br>• “GPU” (Graphics Processing Unit): Is faster than CPU, suitable for VSI mode.<br>• “CPU” (Central Processing Unit): Is slower than GPU, suitable for VSI and PSI mode. |
| 3 | Selection of the z-position step width:<br>• Auto: Default value 1x. Using higher increment value larger step width will be used, resulting in faster measurement speed, at the expense of lower accuracy.<br>• Adjustable: Here a specific step width value (in nm) can be entered.<br><br>Note: Usually no changes to these settings are required. |
| 4 | Trigger source selection:<br>• “Built-in”: Default mode for smartWLI devices. Frame capture trigger will be sent by an internal hardware module within the smartWLI device.<br>• “External”: Is selectable only for smartWLI-OEM devices in stroboscopic mode. Frame capture trigger will be sent by an external hardware module. |
| 5 | Setting for the quality threshold with a value in the interval [0…1]. The threshold can be set using the slider, the spin-control or can be entered directly in the input field. The default value is 0.030. During processing a quality value is calculated for each measured point (pixel). This value indicates how trustworthy the measured point is. A setting of 0.000 indicates that all measured points will be exported to the analysis software. If the value is set to a value larger than 0.000, only measured values with a quality better than the threshold will be exported.<br><br>Important: An incorrectly chosen threshold can cause gaps in the measured data (so-called NM points in the MountainsMap® analysis software). This parameter makes it possible to separate unreliably detected measured data from reliable data. |

<table>
<tr><td></td><td>Note: Gaps in the measured data are acceptable, as they can be interpolated later with the help of the analysis software.</td></tr>
<tr><td>6</td><td>Measurement method selection:

- “VSI” (Vertical Scanning-Interferometry): VSI mode is the default measurement mode of the smartVIS3D software. Here a white-light source with a short coherence length is used. In contrast to the “PSI” mode the “VSI” mode can be used for both rough and smooth surfaces. However for smooth surfaces it yields less precise measurement results than the “PSI” mode.
- “PSI” (Phase-Shifting Interferometry): The “PSI” mode is available as an optional software module. Together with a white-light source of a long coherence length a bandpass filter is used. This method yields very accurate measurement results. However in contrast to the “VSI” mode it is suitable only for smooth surfaces ($R_a$ < 200 nm) without large height jumps. Suitable objects are e.g. wafers, glass and mirrors.
</td></tr>
<tr><td>7</td><td>This option is enabled only in “VSI” mode. For specimens with a smooth surface ($R_a$ < 200 nm) a significantly higher accuracy can be achieved when the option “Smooth” is selected. On the other side, for objects with a rough surface using the option “Smooth” should be avoided. In following figures the achieved measurement results using the option “Rough” (figure on the left) and the option “Smooth” (figure on the left) for the same object are shown.





</td></tr>
<tr><td>8</td><td>Accept the new settings.</td></tr>
<tr><td>9</td><td>Exit the “Measuring Options” dialog without accepting the new settings.</td></tr>
</table>

## 2.3.2. Measuring Procedures Dialog

The measuring procedures dialog can be used to save and reload measuring settings. This applies to the settings in “Measuring options” dialog, see section 2.3.1, to the light settings, the name of the MountainsMap® document template, which is set using the “Choose report template” menu field in the “File” dropdown menu, see section 0, and the upper and lower scan range limits, which are set in the main window, see section 2.1.

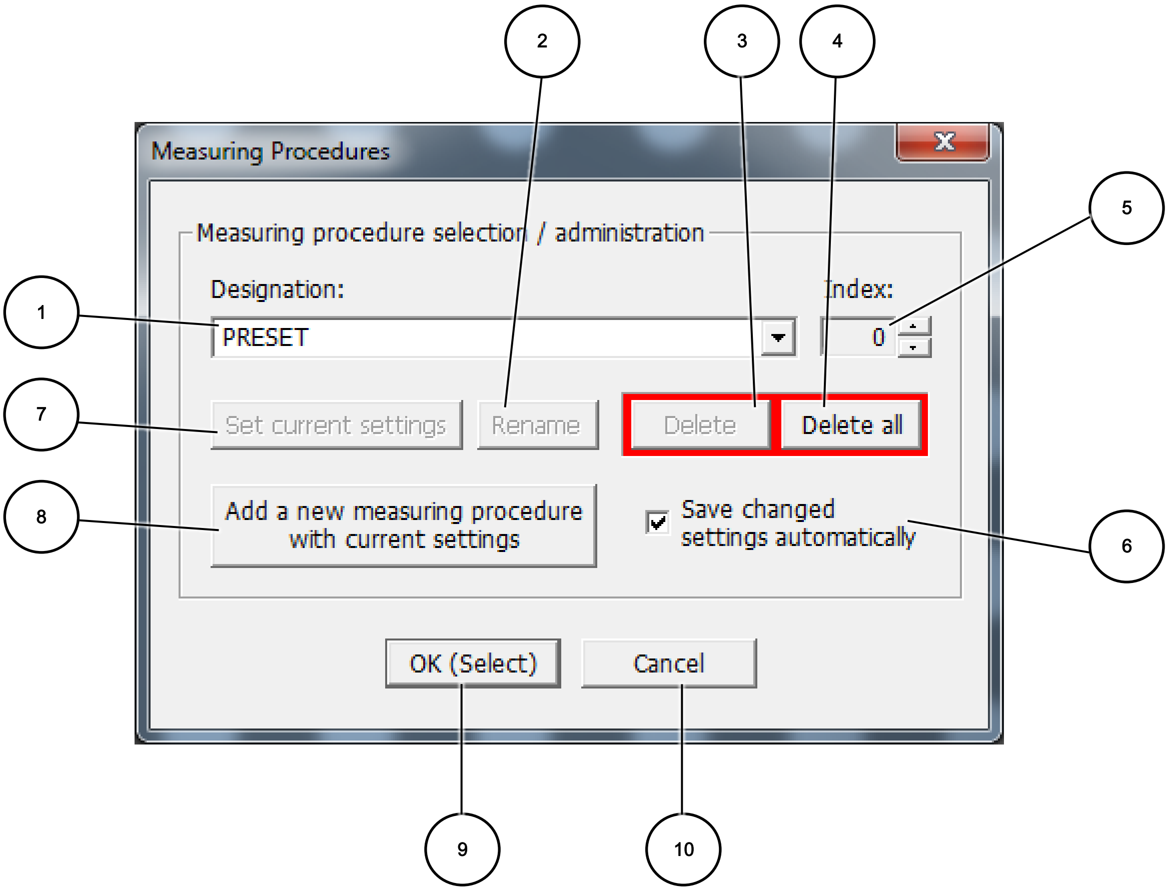



FIGURE 7: SMARTVIS3D MEASURING PROCEDURES DIALOG

| No. | Description |
|---|---|
| 1 | Name of the measuring procedure. To create a new measuring procedure a new procedure name must be entered here before button (8) is clicked. |
| 2 | To rename a measuring procedure it must be selected in (1) then this button must be pressed and afterwards a new name entered in (1). A message box will appear asking you if you really want to change the name of the selected procedure. By pressing “Yes” the selected procedure will be renamed. |

| | |
|---|---|
| **3** | To delete a measuring procedure, select it first in (1) and press then on this button. A message box will appear asking you if you really want to delete the selected procedure. By clicking the “Yes” button the selected procedure will be permanently removed from the list. |
| **4** | Press this button to delete all measuring procedures available. After pressing the “Delete all” button a message box will appear asking you if you really want to delete all available procedures. By pressing the “Yes” button all stored procedures, except the “PRESET” procedure, will be removed permanently from the list. |
| **5** | Index of the selected procedure. |
| **6** | If this option is checked, then all changes will be stored automatically. |
| **7** | Overwrite the settings of the selected procedure by the currently selected settings in “Measuring options” and in “Light control” dialogs. Also the currently selected MountainsMap® document template, which is set using the “Choose report template” menu field in the “File” dropdown menu, and the upper and lower scan range limits defined in the main window will overwrite the corresponding settings in the selected procedure. After pressing the “Set current settings” button a message box will appear asking you if you really want to overwrite the settings of the selected procedure. By pressing the “Yes” button selected procedure settings will be overwritten. |
| **8** | Add a new measuring procedure with current settings.<br><br>Note: To add a new measurement procedure to the list a new name, not yet available in the procedure list, must be entered in field (1) before pushing this button. |
| **9** | Reset all current settings by the settings of in (1) selected measuring procedure and exit the dialog. |
| **10** | Exit the dialog without any changes to current settings. |

## 2.3.3. Position Control Dialog (available only for devices with motorized positioning axes)

Note: This dialog can be used alternatively to a joystick to move the motorized axes of the measurement device.

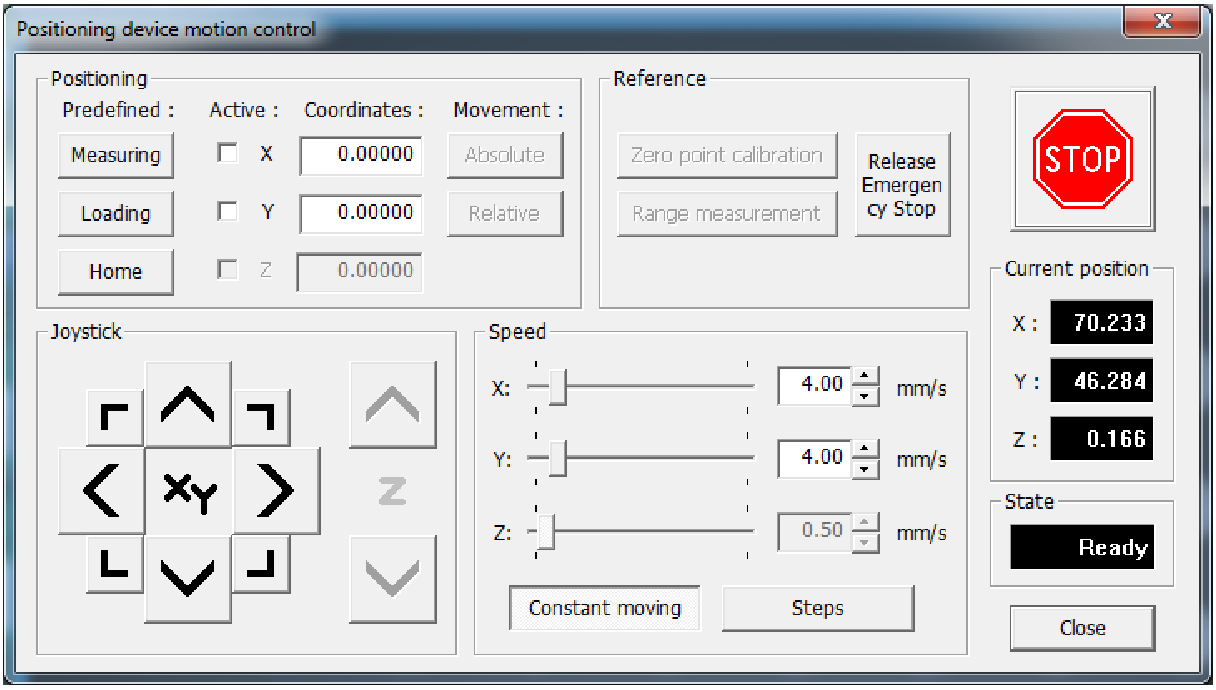



FIGURE 8: SMARTVIS3D POSITION CONTROL DIALOG

| **Control group name** | **Controls description** | |
|---|---|---|
| | **Control name** | **Description** |
| **Positioning** | Measuring (Predefined) | This button is enabled in case a predefined measurement position is available. By clicking on this button the predefined coordinates will be entered automatically to the coordinate fields. To move the motorized stage to these coordinates push the “Absolute” (Movement) button. |

| | | |
|---|---|---|
| | Loading (Predefined) | This button is enabled in case a predefined sample loading position is available. By clicking on this button the predefined coordinates will be entered automatically to the coordinate fields. To move the motorized stage to these coordinates push the “Absolute” (Movement) button. |
| | Home (Predefined) | This button is enabled in case an initial position is available. By clicking on this button the predefined coordinates will be entered automatically to the coordinate fields. To move the motorized stage to these coordinates push the “Absolute” (Movement) button. |
| | X, Y, Z (Active) | Using these check boxes control of the respective axis through the “Positioning Control” dialog can be enabled. A specific check box is enabled only if the positioning device features the corresponding motorized axis. |
| | X, Y, Z (Coordinates) | If an X, Y or Z axis is available and enabled then in the corresponding coordinate field desired coordinates for this axis in mm can be entered. |
| | Absolute (Movement) | This Button is enabled when at least one of the X, Y or Z axis is enabled. By clicking on this button the motorized axes assume new positions corresponding to the provided coordinate values. |

| | | |
|---|---|---|
| | Relative (Movement) | This Button is enabled when at least one of the X, Y or Z axis is enabled. By clicking on this button the motorized axes assumes new positions using the provided coordinate values as relative distance values to the current position. |
| **Reference** | Zero point calibration | Starts a calibration movement procedure to the point of origin position of the motorized stage coordinate system (upper left corner) |
| | Range measurement | Starts a calibration movement procedure to the farthest position (lower right corner) in relation to the point of origin position of the motorized stage coordinate system |
| | Release Emergency Stop | After the emergency stop button on the measurement device is pressed it isn't enough to release the mechanical emergency stop button to be able to proceed with measurements but it is also necessary to release the software emergency lock by pressing this button |
| **Joystick** | Direction Buttons | By clicking on any of these buttons the motorized axes move the positioning table in the corresponding direction. |
| **Speed** | X, Y, Z | Here during any movement used speed for each axis can be adjusted in mm/s using the slider controls, the spin controls or by entering the desired speed value directly into the input fields. |
| | Constant moving / Steps | Movement mode selection:<br>• In "Constant moving" mode as long as the user presses a joystick |

| | | |
|---|---|---|
| | | direction button the motorized axes will execute a continuous motion until the button is released by the user<br>• In “Steps” mode each time the user presses a joystick direction button the motorized axes will execute a corresponding movement in the desired direction for a predefined time period |
| **State** | - | Here the current status of the motorized positioning table is shown. |
| **Current position** | X, Y, Z | Here the coordinates of the current position are shown. |
| **-** | Stop |  Emergency stop button. Press on this button to cancel immediately all movements of the moto-rized positioning table. |
| **-** | Close | Exits the “Positioning Control” dialog. |

## 2.3.4. Light Control Dialog (available only for devices with an integrated light control hardware module)

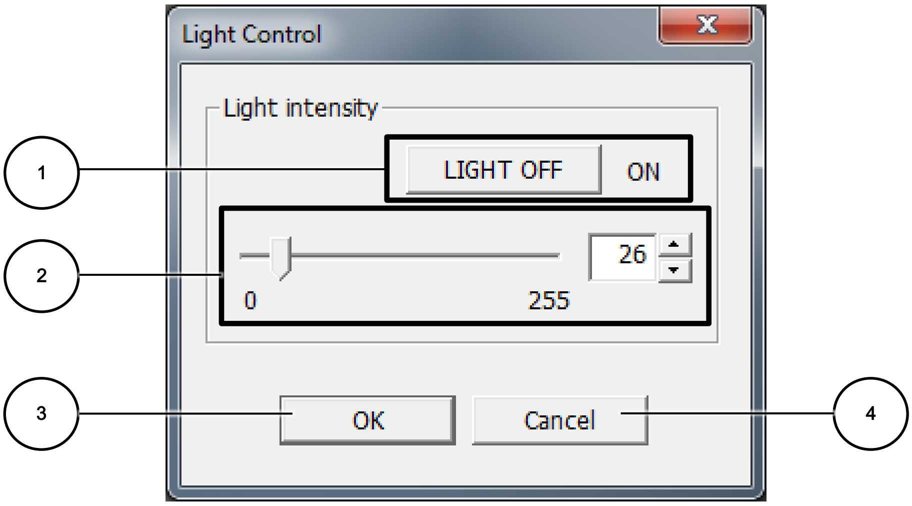



FIGURE 9: SMARTVIS3D LIGHT CONTROL DIALOG

| No. | Description |
|---|---|
| 1 | Turns light on / off. Takes effect immediately. |
| 2 | Light intensity control elements. Using either the scrollbar, the spin-control or by directly entering the desired intensity value in the input field the light intensity can be adjusted. Takes effect immediately. |
| 3 | Store the intensity value and the power status of the led for further usage, e.g. to specify the light settings of a new measurement procedure in “Measuring procedures” dialog. |
| 4 | Discard new settings and restore previous values. |

## 2.3.5. Stitching process

Stitching is a process which makes it possible to measure more than one area and combine the obtained surface profiles to a single large profile. In Figure 10 an example of a stitching process is shown. In this example the results of four single measurements are stitched to a single surface profile.

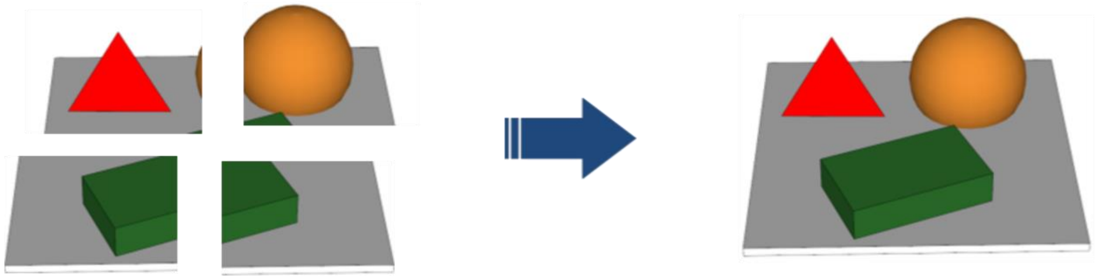


FIGURE 10: STITCHING OF FOUR SINGLE MEASUREMENTS TO A SINGLE LARGE SURFACE PROFILE

To assure correct stitching of surface profiles some overlap of measured areas is required as shown in Figure 11.

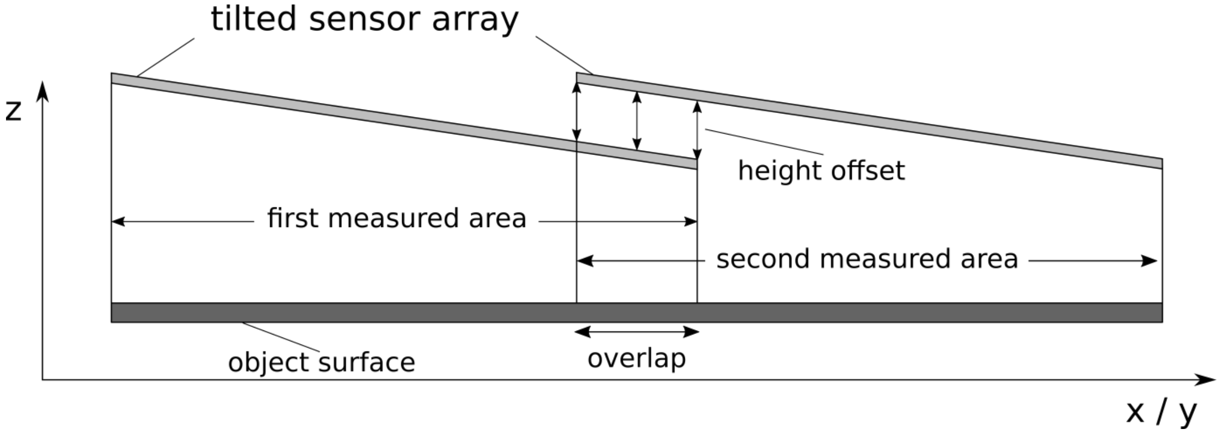



FIGURE 11: FOR CORRECT STITCHING OF TWO INDIVIDUAL MEASUREMENT AREAS REQUIRED AREA OVERLAP

### 2.3.5.1. Auto-stitching process (available only for devices with motorized positioning axes)

If you want to obtain the surface profile of a large object which is not feasible using a single measurement than you can use the auto-stitching functionality of the smartVIS3D® software for this task. The auto-stitching operation mode is accessible through the “Stitching” menu entry of the “Options” menu in the main window of the smartVIS3D® software. Clicking on the “Stitching” menu entry will open the “Stitching-Measurement” dialog shown in Figure 12.

Note: This menu entry is only available for devices equipped with motorized positioning axes in X and / or Y direction. Prior to calling the “Stitching-Measurement” dialog a proper report template file for handling stitching results of the smartVIS3D measurement software must be selected using the “Choose report template” menu entry in the “File” menu, see section 2.2.

After calling the “Stitching-Measurement” dialog the size of the complete measurement area and the overlap of tiles must be specified using the corresponding input fields of the tab “prescan” in the option and control field (3). After these values are entered into the input fields the software automatically computes the required grid tile size in X and Y direction in such a way that the complete measurement area will be scanned. The computed grid will be shown in fields (1) and (2) of the auto-stitching dialog. Field (1) is the stitching grid used for during the “Prescan” procedure captured camera images. Initially the grid tiles of the field (1) have a black background color. Field (2) is used to show the progress status of the stitching procedure. Initially the grid tiles of the field (2) have a grey background color.
After the stitching grid is computed by the software you can adjust it using the controls of the second tab (“manual”) in the option and control field (3). The content of the “manual” tab is shown in Figure 13. Using the “+” / “-“ control buttons for specific directions in the “multiplier” field specified number many rows respectively columns can be added or removed to and from the stitching grid.

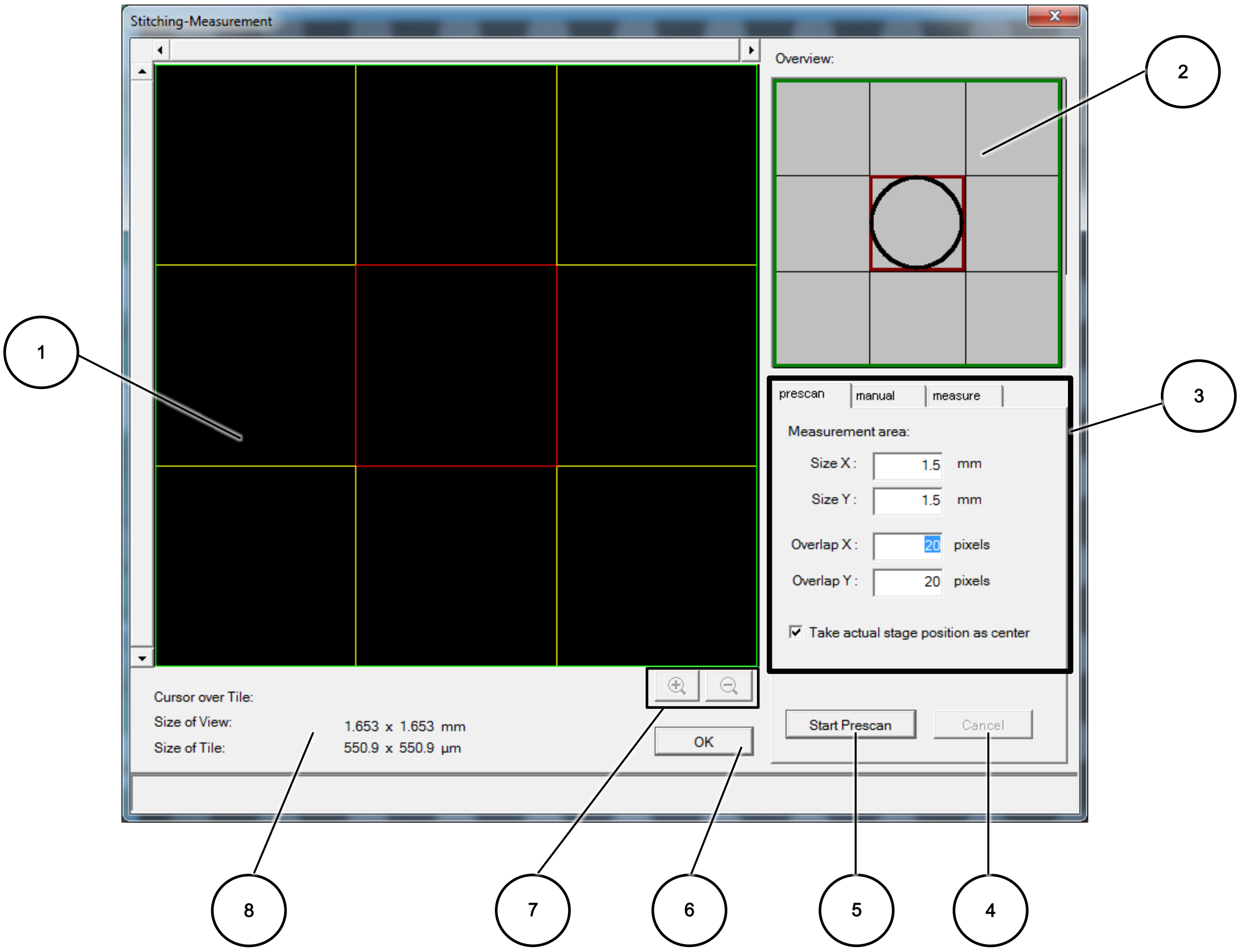



FIGURE 12: SMARTVIS3D "STITCHING-MEASUREMENT" DIALOG

After the grid satisfies the requirements of your measurement task press on the "Start Prescan" button of the "prescan" tab in the option field (3). By calling the "Prescan" procedure the motorized positioning stage will automatically assume measurement positions corresponding to the grid tiles at each of which the camera will capture a single frame of specimen's surface. These frames will be shown in the grid field (1) of the "Stitching-Measurement" dialog. Additionally the grid tiles of grid field (2) will be assigned a chartreuse background color. In Figure 14 an example of a 3x3 camera frames grid with captured camera frames and of a 3x3 progress status grid are shown.

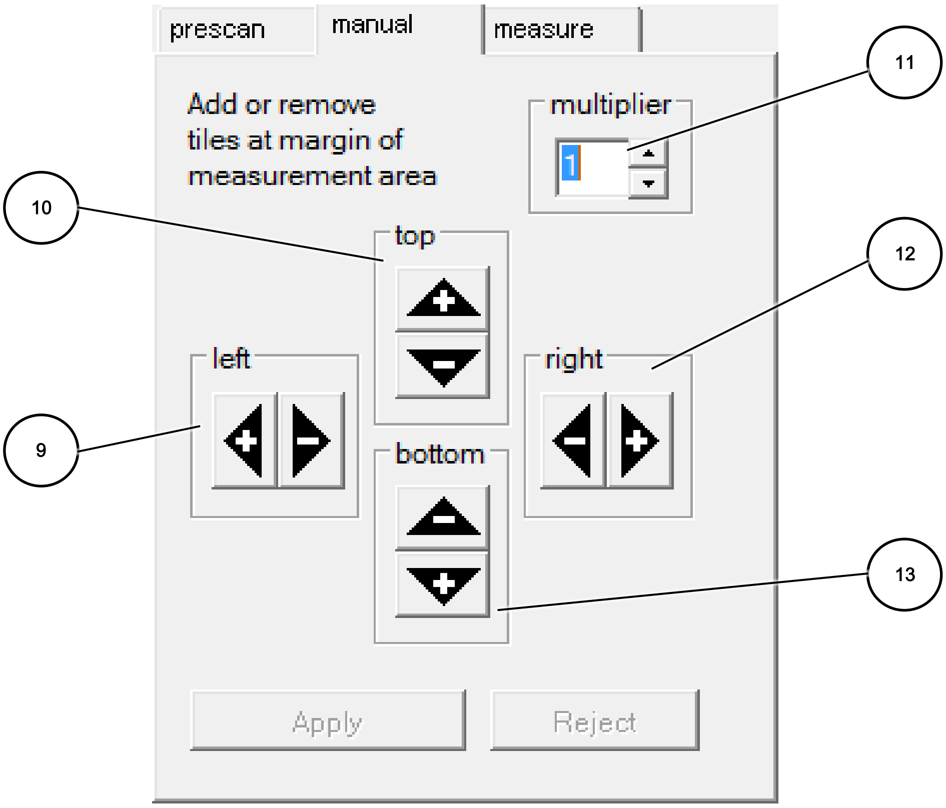



FIGURE 13: THE "MANUAL" TAB OF THE "STITCHING-MEASUREMENT" DIALOG

Using the frames shown in the grid field (1) you have to check if tiles are properly aligned to each other. Structures on specimen's surface which stretch across multiple tiles may simplify this task as in many cases it can be easily seen whether segments of a single structure located in adjacent tiles are misaligned or not. If tiles are not properly aligned a calibration procedure for the measurement device is required. For details on calibration procedure see section 3.7.

In case that the tiles are properly aligned and the size of the grid satisfies the requirements of your measurement task you can proceed with the actual stitching measurement. Change to the tab "measure" in the option field (3), shown in Figure 15, and click on the "Start" button to perform the measurement procedure. Using the information of the grid the software takes control over the motorized stage and the camera and executes the complete scan and data analysis procedure on each grid tile.

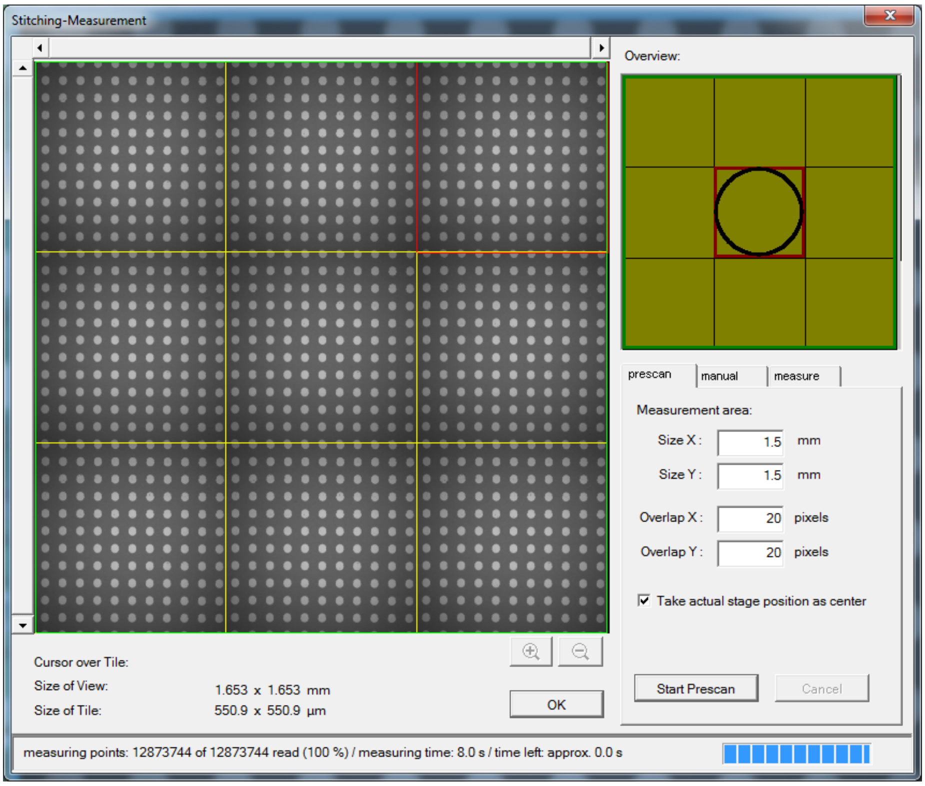



FIGURE 14: SMARTVIS3D "STITCHING-MEASUREMENT" DIALOG AFTER THE PRESCAN PROCEDURE

When the stitching measurement process is running, to show the progress of the stitching procedure in the camera grid field (1) the currently scanned grid tile is highlighted using a red border. Because in the initial state the center tile is assigned the red border, to avoid confusion during the measurement it will be assigned a purple border. Each processed tile will be additionally marked with a green background color in the progress status grid (2). In Figure 16 an example of the updated grid tiles is shown.

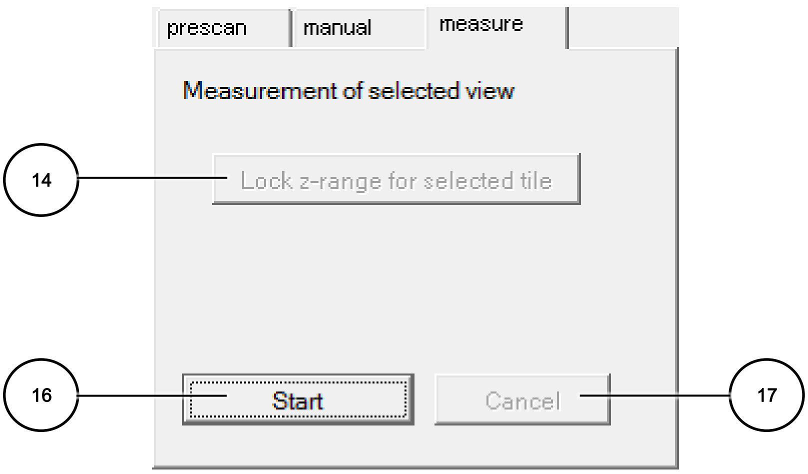



FIGURE 15: THE "MEASURE" TAB OF THE "STITCHING-MEASUREMENT" DIALOG

After all tiles are processed press the “Ok” button. In the measurement results directory you will find grid time number many result files which you can view in the MountainsMap® analysis software. Although the smartVIS3D “Stitching-Measurement” is called stitching process the smartVIS3D software does no actual stitching of multiple result files to a single result file, but provides only a simpler way to scan multiple overlapping areas which can be stitched by additional software. MountainsMap® is capable of stitching the obtained result files. Refer to the manual of the MountainsMap® analysis software for more details.

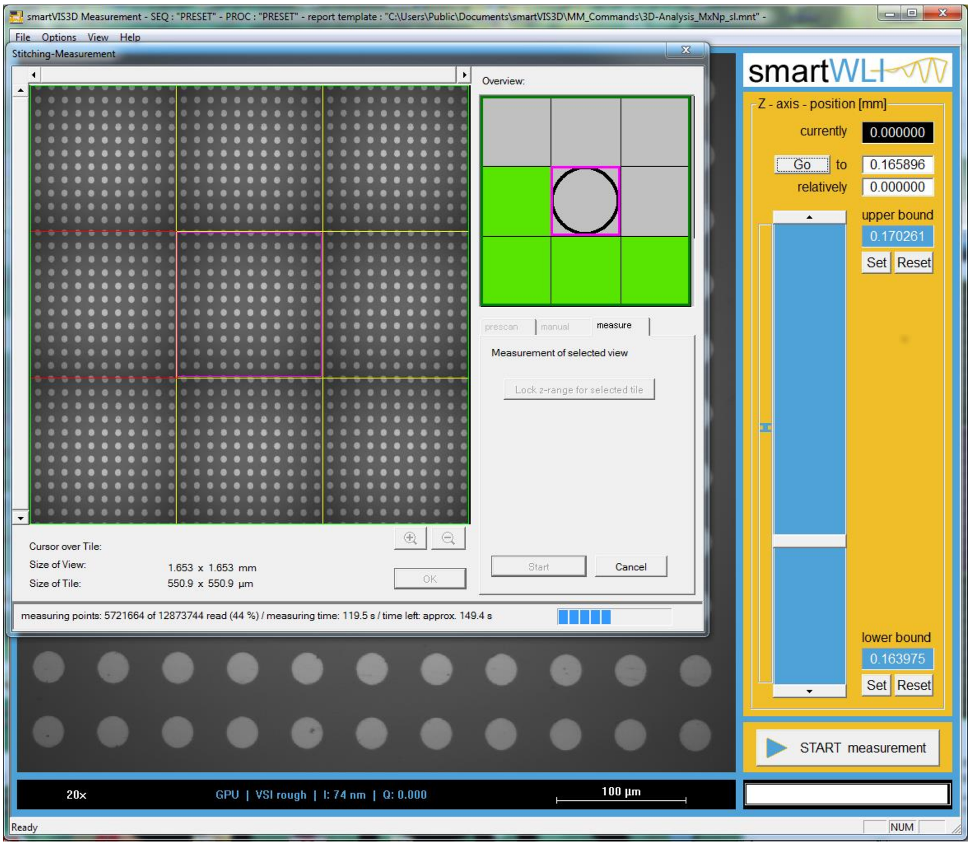



FIGURE 16: DISPLAY OF THE STATUS PROGRESS DURING THE STITCHING-MEASUREMENT PROCEDURE

The following table contains a short description of control elements for the “Stitching-Measurement” dialog:

| No. | Short description |
|---|---|
| 1 | Stitching grid used for captured camera frames. At startup each grid tile has a black background color. After execution of the “Prescan” procedure each grid tile contains a single camera frame of specimen’s surface captured at to the specific grid tile corresponding measurement position. |

| | |
|---|---|
| **2** | Stitching grid used to display the progress of currently running stitching process. Each already processed grid will be marked with a green background color. |
| **3** | Options and procedure control field with three groups of controls.<br>1. "Prescan": Contains information about the size of the complete measurement area and the overlap size of grid tiles. Furthermore using "Take actual stage position as center" option the center of the grid can be specified.<br>2. "Manual": Contains control elements which are used to add new rows and columns to and remove rows and columns from the stitching grid.<br>3. "Measure": Contains control elements which are used to start and to cancel the stitching measurement procedure. |
| **4** | This button is available under the tab "Prescan" of the option field (3) and it is enabled if a "Prescan" procedure is currently running. By pressing this button a currently running "Prescan" procedure can be canceled. |
| **5** | This button is available under the tab "Prescan" of the option field (3) and it is enabled if no "Prescan" procedures are running. By pressing this button the "Prescan" procedure will be called and executed. |
| **6** | Exit the "Stitching-Measurement" procedure. |
| **7** | If the grid size is larger than three tiles in a single direction, these controls will be enabled otherwise they are disabled. Pressing on the "-"-zoom button you can zoom out and see more than 3x3 tiles. Pressing on the "+"-zoom button you can zoom in up to 3x3 tiles. |
| **8** | Information about the view and the tile size. In case the mouse cursor is hovering on top of a tile the index of this tile will be shown here too. |
| **9** | Add / Remove a tile column on the left side of the grid. |
| **10** | Add / Remove a tile column on top of the grid. |

| | |
|---|---|
| **11** | Specifies the number of columns respectively rows which are inserted or removed on a single click on buttons 9, 10, 12 and 13. |
| **12** | Add / Remove a tile column on the right side of the grid. |
| **13** | Add / Remove a tile column on bottom of the grid. |
| **14** | Lock the z-range movement for the selected tile. To select a tile press with the left mouse button on the desired tile. |
| **15** | Start the stitching measurement procedure. |
| **16** | Cancel the running measurement procedure. |

### 2.3.5.2. Manual stitching process

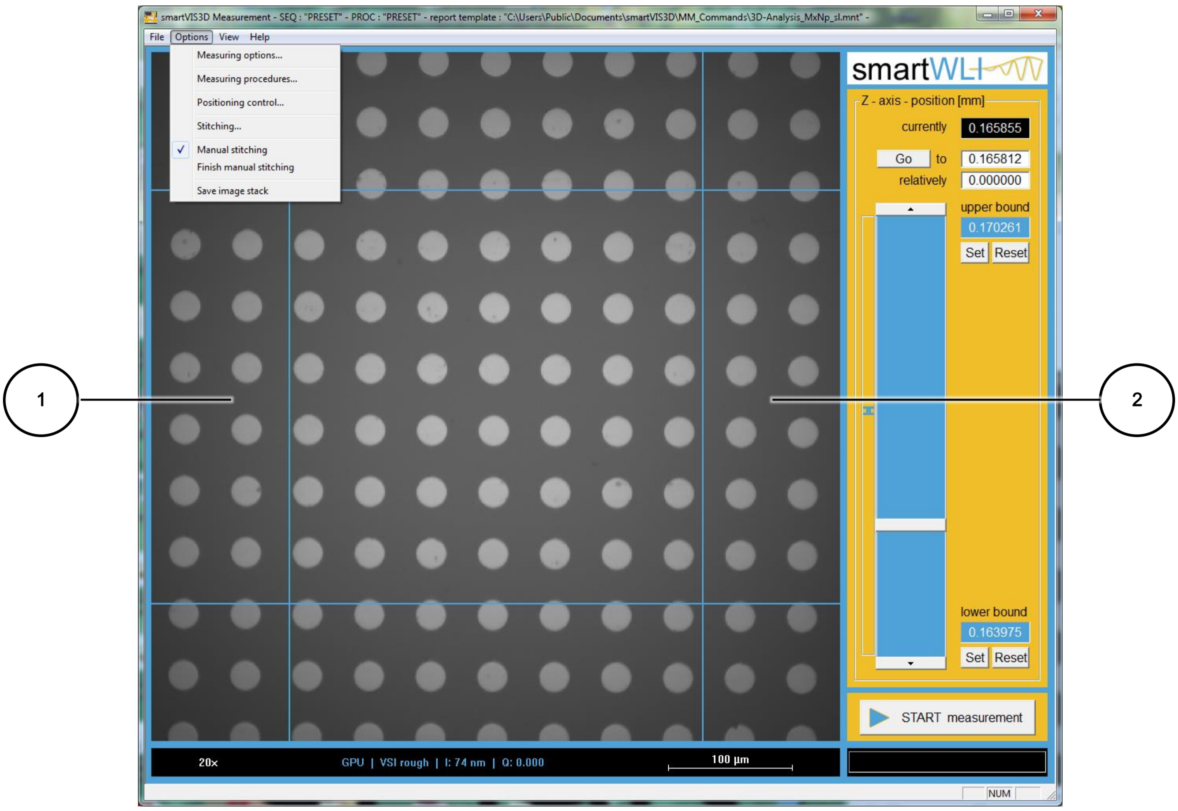



FIGURE 17: MANUAL STITCHING OVERLAP AREAS

In case your device has no motorized but a manual positioning stage you can use the manual stitching guide lines to simplify the measurement process for large objects. To make the guide lines visible in the “View menu” under the menu entry “Auxiliary lines / grids” the menu entry “Manual stitching overlap areas” must be enabled, see section 2.4. Additionally you have select “Manual stitching” menu option in the “Options” menu. The guide lines serves only as orientation guides as they show the overlap areas around the current grid tile area which is in the center of the live view. After enabling the overlap areas you have to manually start measurement procedure at each new grid tile and you have to adjust the position of the stage also manually in such a way that the overlap condition specified by MountainsMap® (approximately 20% of the tile area) and shown in Figure 11 is satisfied. E.g. after executing a measurement procedure on the tile shown in Figure 17 the grid tile on the left of this tile has to be scanned. For that the positioning stage must be moved to the right until the overlap area (1) on the left of the previous tile is on the right (2) of the new grid tile. After scanning as many as necessary tiles click on “Finish manual stitching” menu entry in the “Options” menu. Like in the auto-stitching mode in the measurement results directory you will find grid time number many result files which you can view in the MountainsMap® analysis software.

## 2.4. View Menu

Note: The view menu does not contain any items to call up dialogs. Instead various settings concerning the main dialog can be changed by checking or unchecking the view menu items.

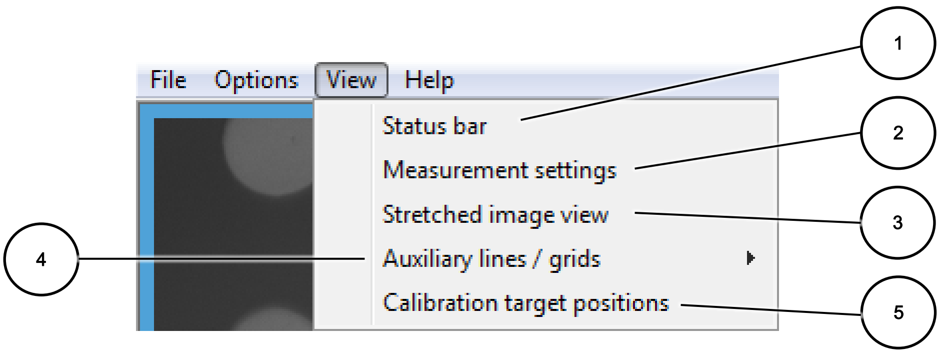



FIGURE 18: SMARTVIS3D VIEW MENU

| No. | Description |
|---|---|
| 1 | Show or hide the status bar in the main dialog. |

| | |
|---|---|
| 2 | Show or hide the measurement settings in the main dialog. |
| 3 | Because the camera resolution is larger than the size of the live view image only a partition of the camera frame is shown in the live view. To see the whole image enable this option. |
| 4 | Show or hide guide lines. |
| 5 | Show or hide calibration target positions. |

## 2.5. Help Menu

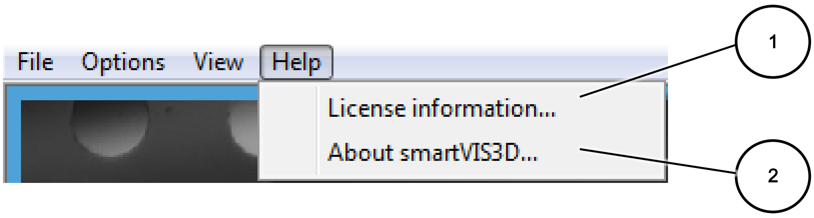
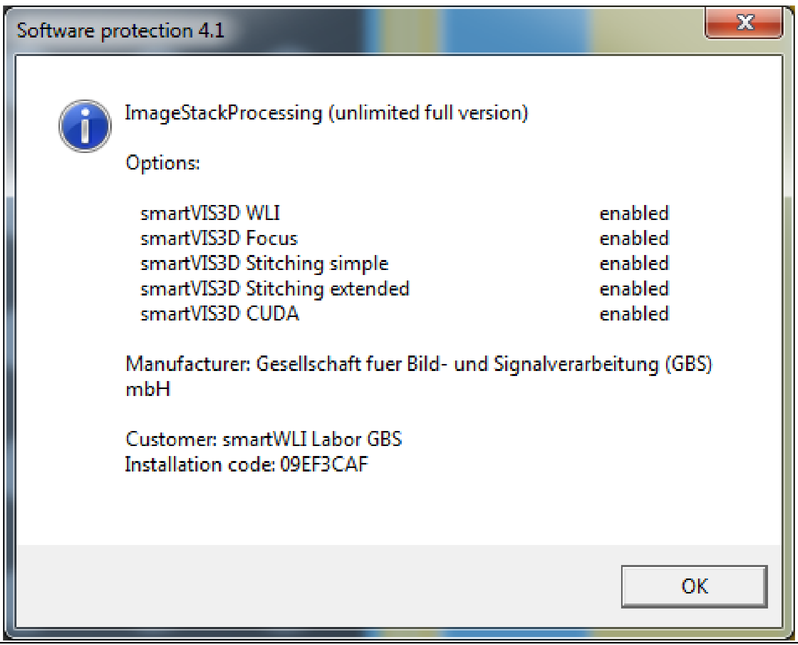
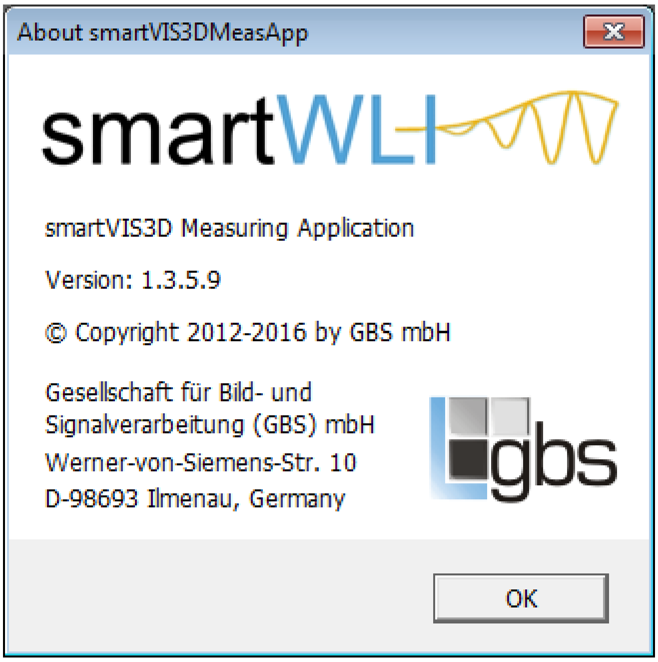



FIGURE 19: SMARTVIS3D HELP MENU

| No. | Description |
|---|---|
| 1 | Opens the "Software protection" dialog which shows information regarding available software modules and licenses, as shown in the following figure:  |

<table>
<tr>
<td>2</td>
<td>Opens the “About smartVIS3D” dialog which shows version information of the smartVIS3D software, as shown in the following figure:<br>


</td>
</tr>
</table>

# 3. Measurement procedure

## 3.1. Requirements

### 3.1.1. Specimen

- Used specimen must be clean (free of grease and dust)
- Used specimen must be dry
- Specimen's surface should be as smooth as possible in order to achieve the highest possible measurement accuracy
- Height discrepancy of points on specimen's surface should not exceed the maximum measurement range of 400 µm to assure that for each surface point the necessary data required for computation of its height value is measured
- The overall height of the specimen should not exceed 50 mm, which is the height limit of smartWLI measurement devices resulting from the fixed stand and drives used in these devices
- In case that the measurement system is equipped with a tilting stage, do not use specimens with a total mass larger than 1 kg in order to avoid any mechanical damage to the measurement system and / or the specimen

### 3.1.2. Environment

- A low-vibration or an environment free of vibration is recommended for optimal measurement results
- The environment of the measurement system should be dry
- The environment of the measurement system should be dust-free or provides a low dust level
- The environment of the measurement system should feature uniform and stable ambient conditions ($\Delta T < 1.0$ K/h) and also a low and constant humidity

Note: For more information on the optimal environment characteristics please refer to the hardware manual of your purchased measurement device.

## 3.2. Prior to a measurement

- Please check whether the measurement task requires protective clothing (gloves, safety helmet, lab coat, protective shoes etc.)
- If the measurement system had been just transported to the current site, set it up as necessary in accordance with the hardware manual purchased with the device
- After setup perform a visual check for any damages. Damaged components must be repaired or replaced before a measurement procedure is conducted
- In case that the measurement device is equipped with a tilting stage, please check the distance of the objective to the tilting stage and correct if necessary to avoid any damage to the measurement system and to provide sufficient distance to specimen's surface. If the distance is adequate the specimen can be placed on the tilting stage
- Place the specimen carefully on the tilting stage and position it as appropriate for your measurement task

## 3.3. Measurement

The measurement system has been calibrated by the manufacturer and is ready to use. After the system has been switched on, the current camera image (live image) is shown in the main window of the smartVIS3D measurement software. To obtain the height profile of a specimen's surface following steps must be conducted:

1. If not already done so, place the specimen on the tilting stage, if available, or on the positioning table of your measurement device
2. Perform a coarse adjustment of the illumination intensity using steps described in section 3.4
3. Configure the measurement options
4. Level the specimen as necessary
5. Focus the image and find interference fringes using the z-drive hand wheel of your measurement device. Please refer to the hardware manual of your device to find the z-drive hand wheel.
6. Perform a fine adjustment of the illumination intensity using steps described in section 3.4

7. Set the upper and the lower limits for the scan range. Detailed description of the required steps in VSI mode can be find in section 3.8 and for the PSI mode in section 3.9
8. Start the measurement procedure

## 3.4. Adjusting the illumination

If too much light is illuminated from the LED than the reflected and by the camera sensor captured amount of light may be as large that the effect of overexposure arises. In such a case yellow pixels appear in the grayscale video image shown in the live view window, see Figure 20.

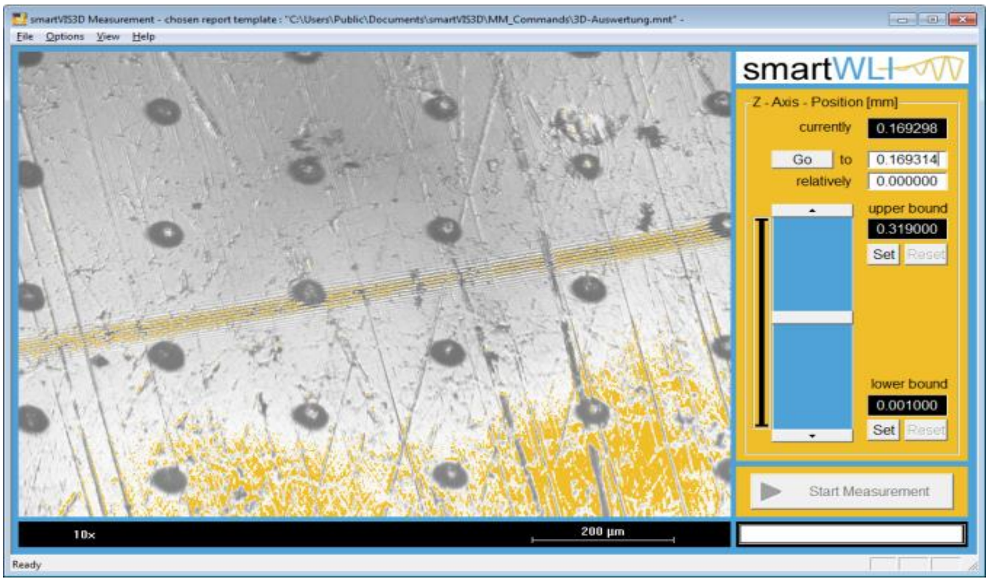



FIGURE 20: OVEREXPOSURE IN CASE OF INCORRECT ILLUMINATION

This effect can be especially seen when interference fringes are visible in the live view image. If yellow pixels appear in the live view please reduce the illumination intensity using the control dial on the LED illumination control until the yellow pixels disappear. However, sufficient brightness must remain such that measurable interference fringes may arise and thus for computation of the height profile required data can be assessed during the measurement procedure.

## 3.5. Configuration of measurement options

Before beginning measurements on new specimen's surface, consideration should be given to the necessary settings in the "Measuring Options" dialog, see section 2.3.1ff.

# 3.6. Leveling the system (applies only for measurement devices with a tilting stage)

A well-leveled measurement system significantly improves the measurement accuracy. Therefore it is important to perform the leveling procedure after each disassembly and setup. Following steps are required to level a measurement system equipped with a tilting stage:

1. Place a suitable specimen or a plane mirror on the tilting stage of your measurement device. Ensure that the specimen / mirror is placed firmly on the stage
2. Using the z-drive hand wheel of your measurement device search for interference fringes in the live view
3. If interference fringes have been found but these are too thin for useful measurements, in this case the fringes fill only a small fraction of the live view image as shown in Figure 21, then a leveling procedure is required

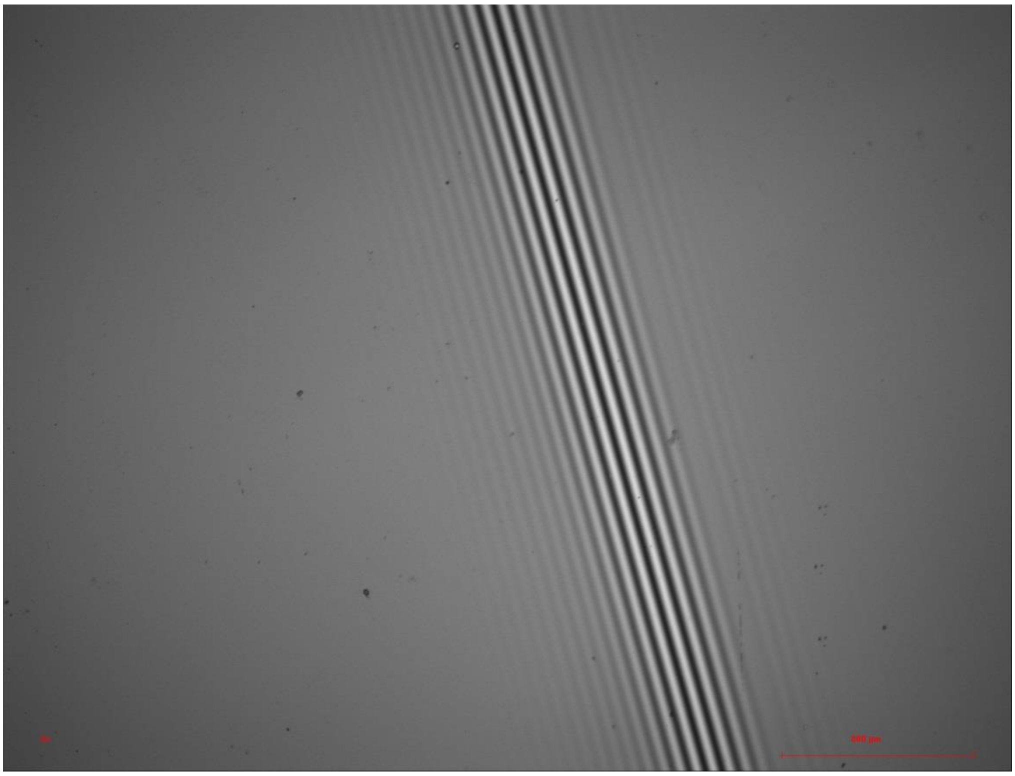


FIGURE 21: MEASUREMENT SYSTEM IS NOT LEVELED, THUS OBTAINED INTERFERENCE FRINGES ARE TOO THIN AND APPEAR ONLY IN A SMALL REGION OF THE LIVE VIEW IMAGE

4. The smartVIS3D software provides specific guide lines which can be used to simplify the leveling procedure. You can find the guide line options using “Auxiliary lines / grid” menu entry of the “View” menu in the main dialog. If you have a tilting stage with 45° inclination adjustment use the “Auxiliary grid 45°” option, otherwise the “Auxiliary grid 90°” option. In following it will be assumed that the measurement device is equipped with a 45° inclination tilting stage. In Figure 22 you can see the enabled 45° guide lines

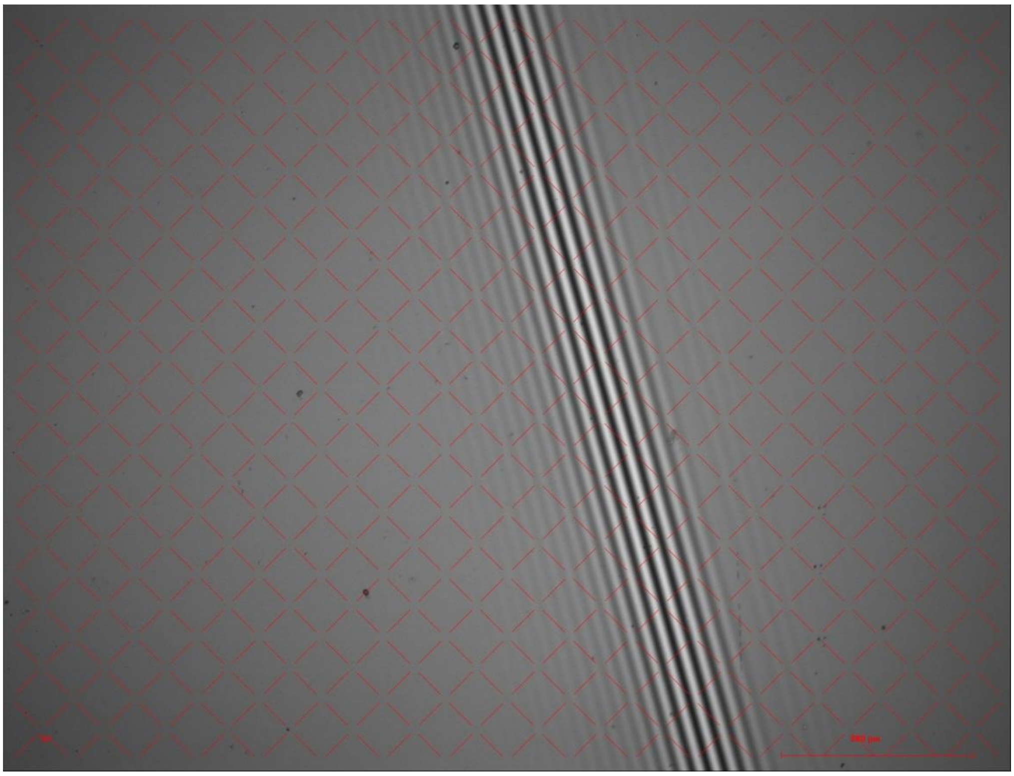


FIGURE 22: ENABLED 45° AUXILIARY GRID LINES

5. Try to align the interference fringes with the grid lines using the tilting screws. Turning a screw clockwise will lift the corresponding table corner. Turning a screw anticlockwise will lower the corresponding table corner. In case of incorrect leveled tilting stages adjusting the height level of a tilting screw will change the orientation of the visible interference fringes. For the orientation of the interference fringes as shown in Figure 22 turning the left screw clockwise will rotate the interference fringes anticlockwise. In Figure 23 for correct leveling required alignment of interference fringes with the grid lines achieved by turning the left screw clockwise is shown

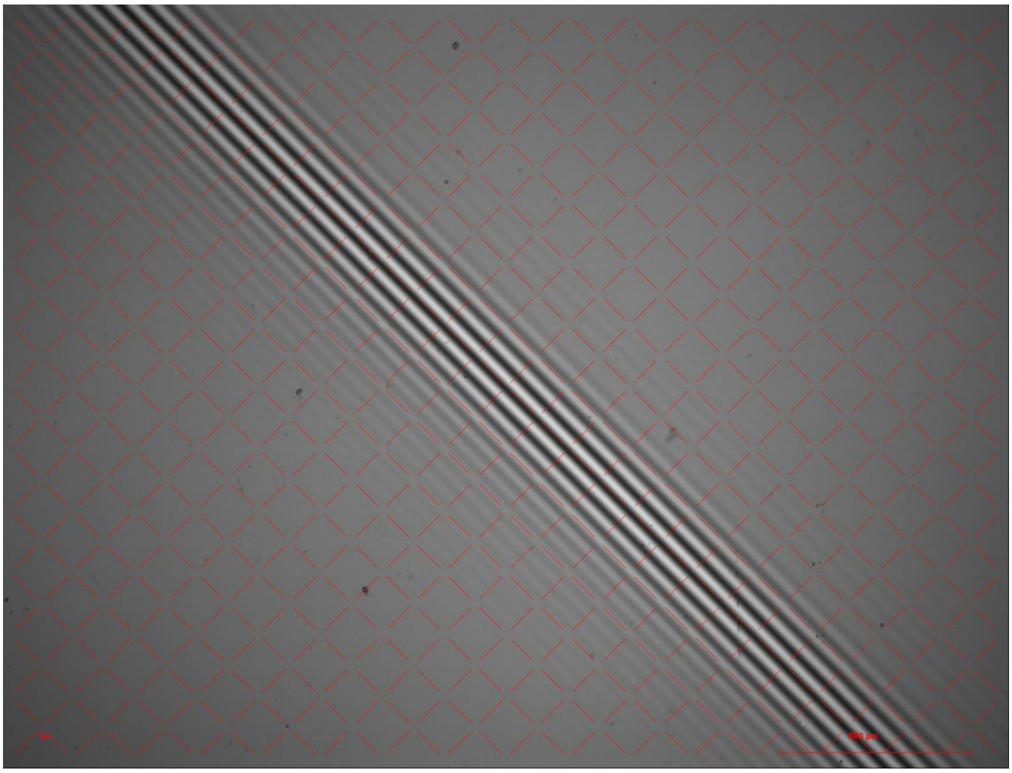
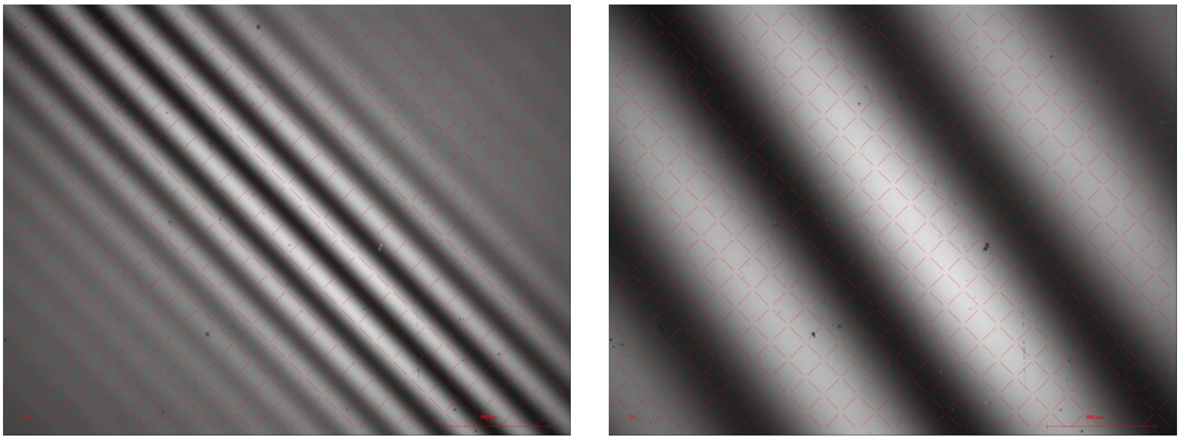


FIGURE 23: WITH THE GRID LINES ALIGNED INTERFERENCE FRINGES

6. After the interference fringes are aligned turn the second screw, in this example the right screw, to tilt the stage perpendicularly to the visible interference fringe pattern. In doing so the interference fringes will expand as shown in Figure 24a and Figure 24b



(a) (b)

FIGURE 24: EXPANSION OF INTERFERENCE FRINGES

7. As can be seen in Figure 24b if the tilting stage is not yet properly aligned the 45° orientation of the interference fringes will drift. In this case readjust the alignment of the interference fringes with the guide lines using the first tilting screw, in this example the left screw. In Figure 25 the accurately aligned interference fringe pattern is shown

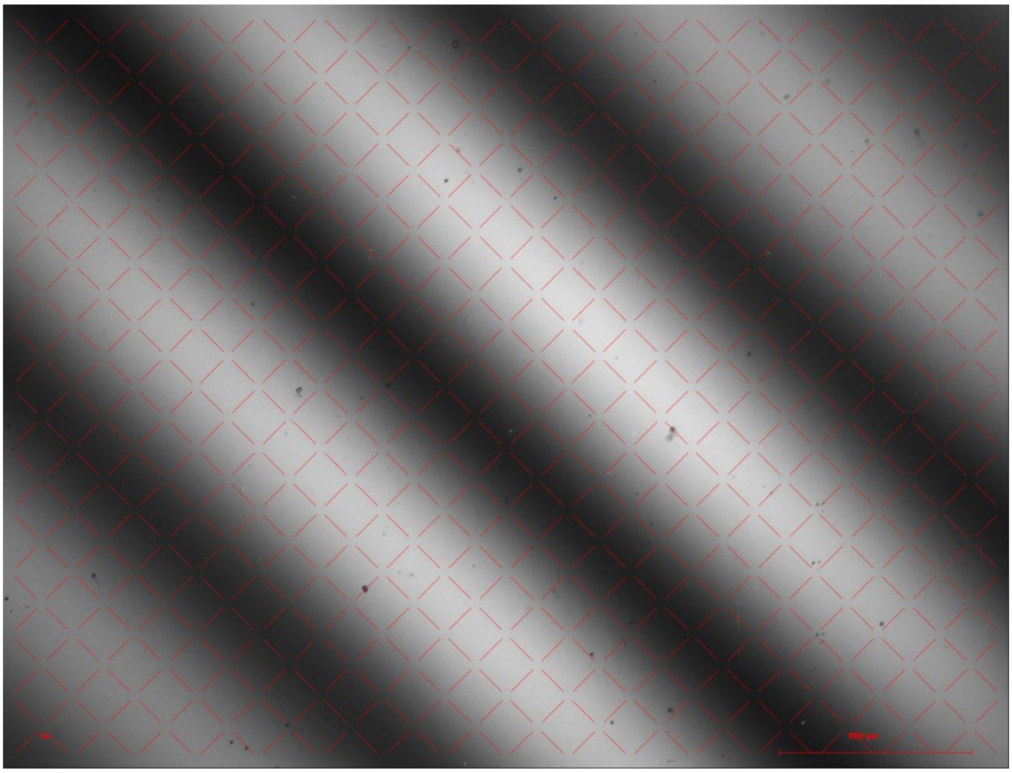


FIGURE 25: READJUSTED ALIGNMENT OF THE INTERFERENCE FRINGES WITH THE SHOWN GUIDE LINES

8. After the interference fringes are properly aligned turn the second screw again to tilt the stage perpendicularly to the interference pattern. Proceed with the leveling procedure until the interference fringes expand evenly over the entire area visible in the live view image as shown in Figure 26

9. Due to adjustments of the level of the tilting stage the image focus may be loosed and thus the interference fringes may disappear. In this case please readjust the z-position of the objective using the z-drive hand wheel of the measurement device until the interference fringes appear again in the live view window

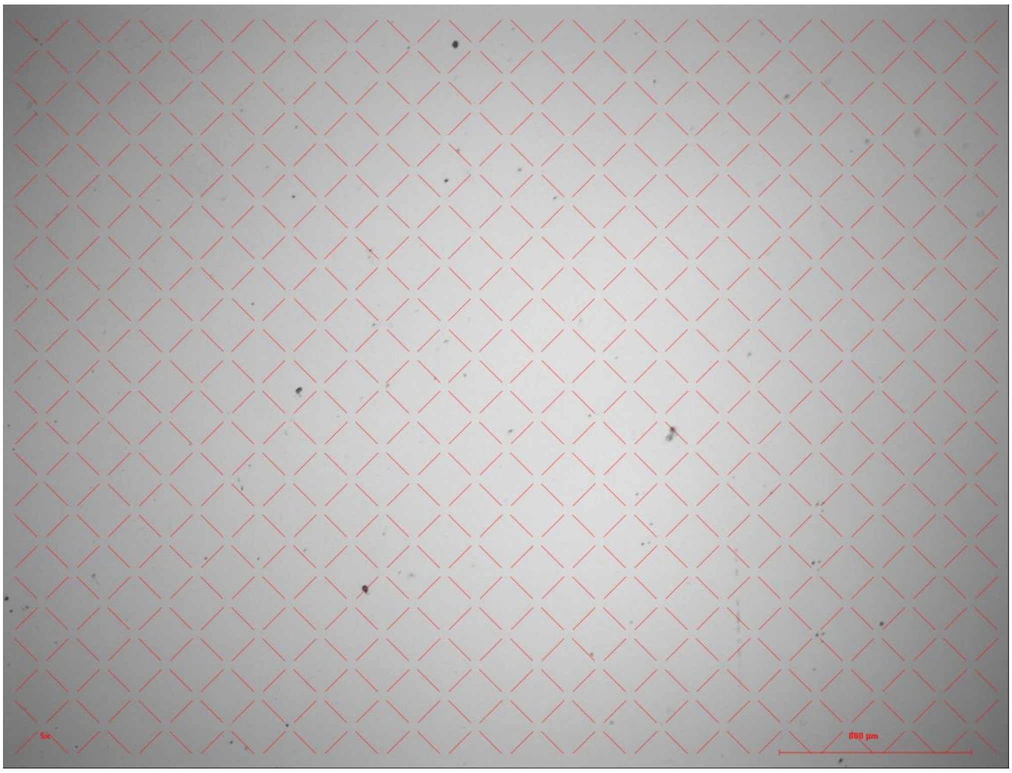


FIGURE 26: INTERFERENCE PATTERN VISIBLE IN CASE OF A PROPERLY ALIGNED TILTING STAGE

# 3.7. System calibration

The measurement system is calibrated by the manufacturer before delivery. When used correctly no recalibration is required. However, recalibration of the measurement device is required each time the objective is replaced. Following steps are required to calibrate the measurement system:

1. If not already done so, switch the measurement system on
2. Start the measurement software smartVIS3D
3. Open the “File” menu and click on “Start calibration procedure” (1), see Figure 27, to start the calibration

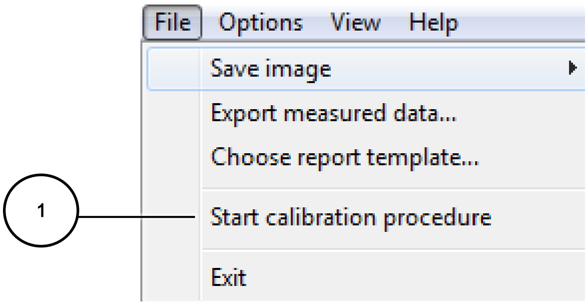



FIGURE 27: "START CALIBRATION PROCEDURE" ENTRY IN "FILE MENU"

4. After pressing on “Start calibration procedure” menu entry a series of instruction dialogs will be opened after another, each of which you must read carefully
5. In the first instruction dialog, see Figure 28, the selected objective and the magnification factor are shown. Verify that these correspond to the settings in the “Measuring Option” menu. If not cancel the calibration procedure by clicking on the “Cancel” button. If the settings are correct confirm that by clicking on the “OK” button

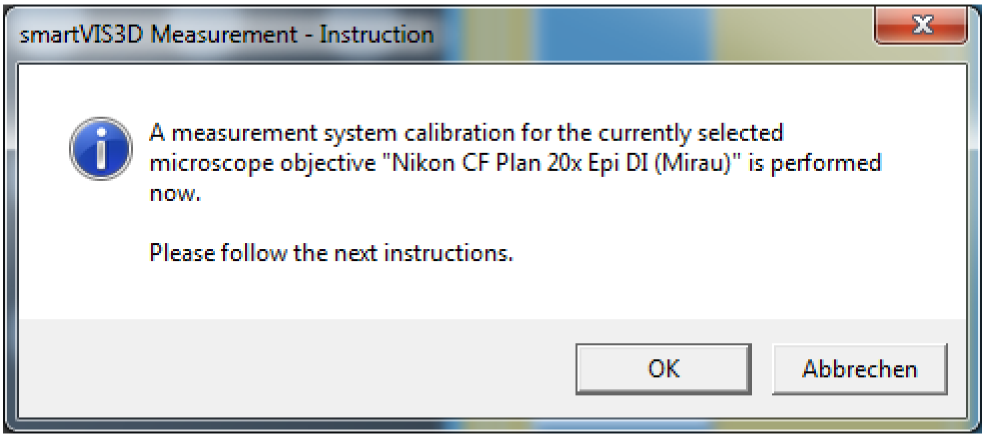



FIGURE 28: FIRST INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

6. The second instruction dialog provides information about a calibration target corresponding to the selected magnification factor, see Figure 29. Make sure to use the correct calibration target, because only if the proper target is used a correct calibration of your measurement device is feasible
   a. The coated side of the calibration target must be at the bottom
   b. For measurement devices with a tilting stage correct leveling of the stage must be assured. Therefore cancel the calibration procedure after placing the calibration target on the tilting stage and proceed with the leveling, as described in section 3.6. After the measurement device is well-leveled repeat calibration steps 1 – 5 and continue the calibration procedure with step 7

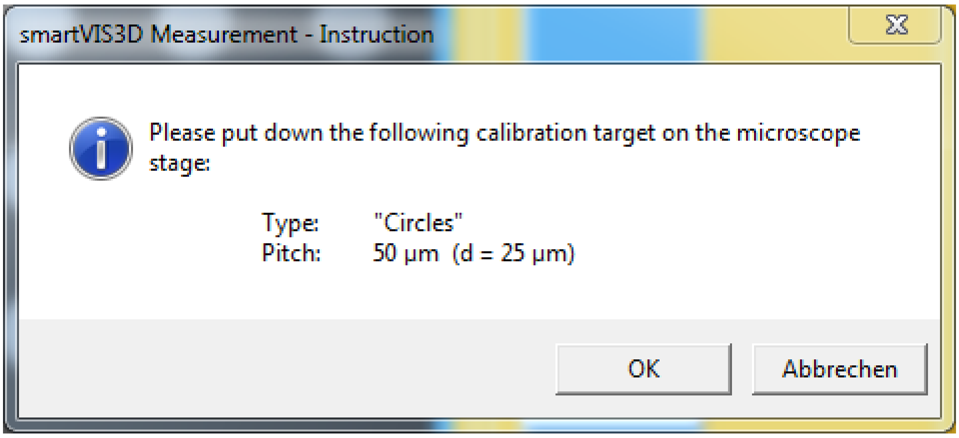



FIGURE 29: SECOND INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

7. Push the “OK” button of the second instruction dialog to proceed to the next dialog
8. In the third instruction dialog, see Figure 30, you will be asked to position the calibration target and to adjust the height of the measurement stage using the z-drive hand wheel such that:
    a. The calibration target is shown area-wide in the whole live view image
    b. It lies in focus of the objective and in the live view a contrast-rich image is shown

    Perform illumination adjustments if necessary, see section 3.4 for details. In Figure 31 an example of desired results is shown. Push “OK” to proceed to the next dialog

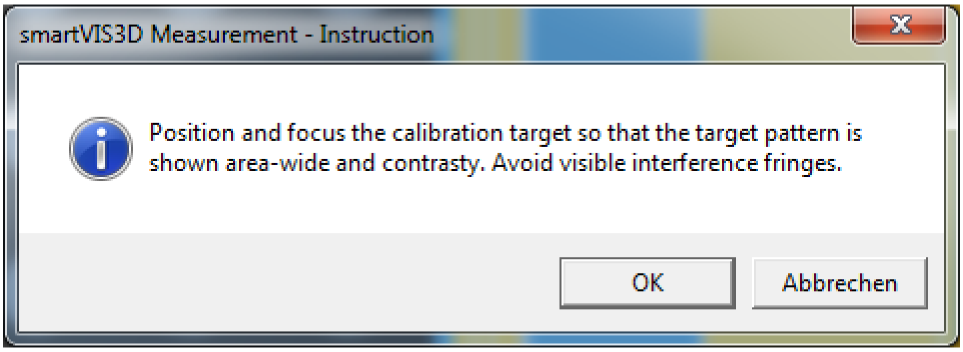



FIGURE 30: THIRD INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

9. The actual calibration is done using a series of measurements at three different positions, meaning that after a measurement series is completed the position of the calibration target must be adjusted using the x-y hand wheels of the microscope stage. At each new position conditions 8a and 8b must be satisfied

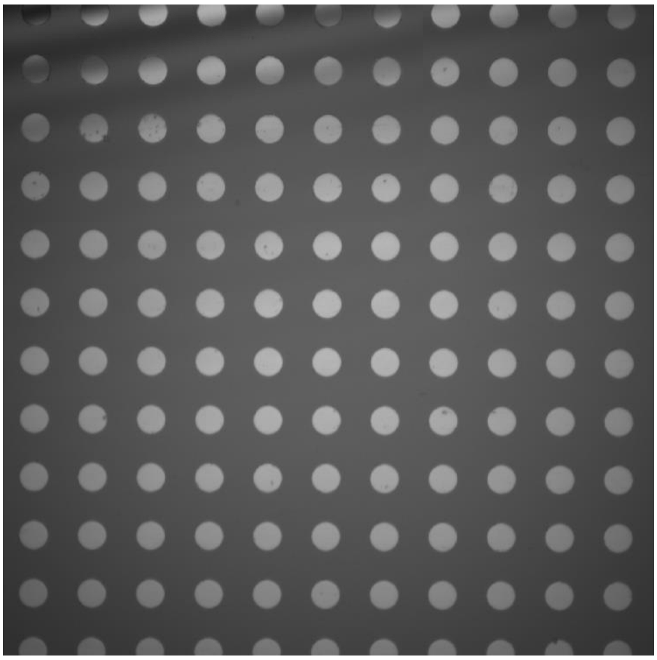


FIGURE 31: A CONTRAST-RICH, OVER THE WHOLE LIVE VIEW FIELD EXTENDED IMAGE OF THE CALIBRATION TARGET

a. In the fourth instruction dialog, see Figure 32, you will be asked if you want to start the calibration measurement series at the first calibration position. By clicking the "YES" button the calibration at the current position shown in the live view of the main dialog will be executed

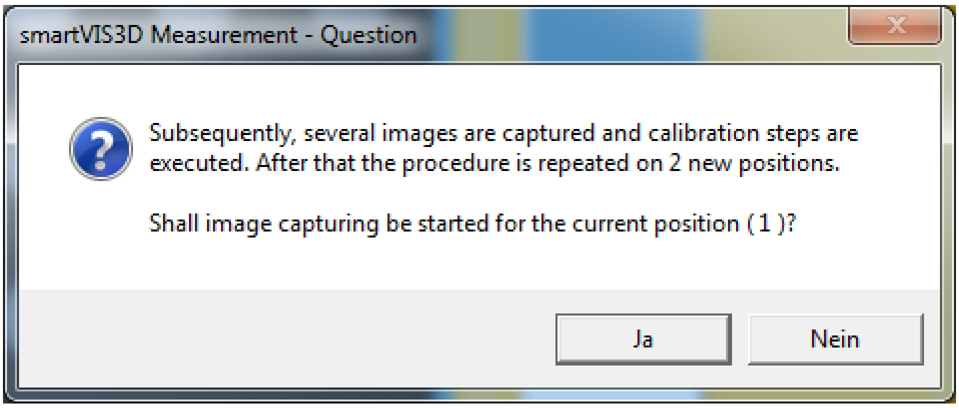
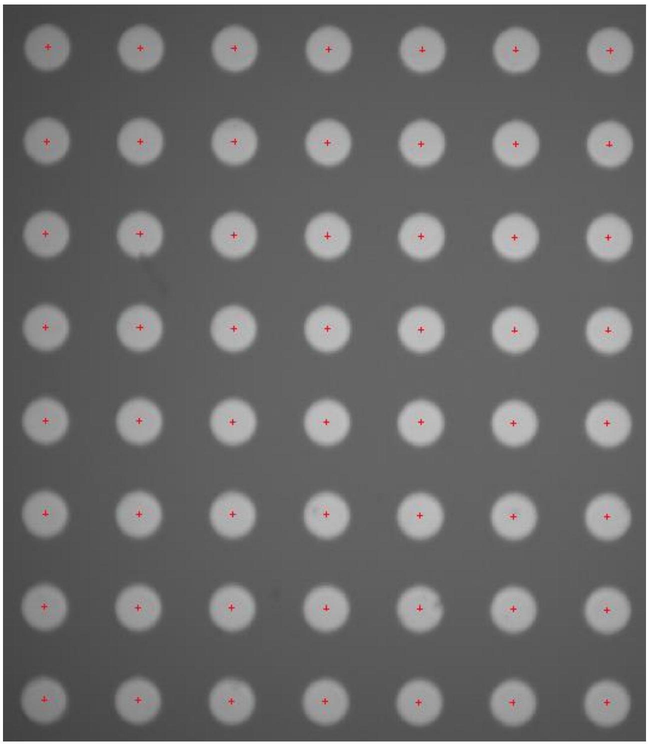



FIGURE 32: FOURTH INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

b. If the calibration procedure was successful red crosses will appear in the center of the circles as shown in the following figure:



After the series of measurements at the first position is completed the dialog shown in Figure 33 will be automatically opened. In this dialog you will be notified that the first measurement series is completed. Additionally you will be asked to change target's position using the x-y hand wheels of the microscopic stage to proceed with the second series of measurements. Make sure that conditions 8a and 8b are satisfied

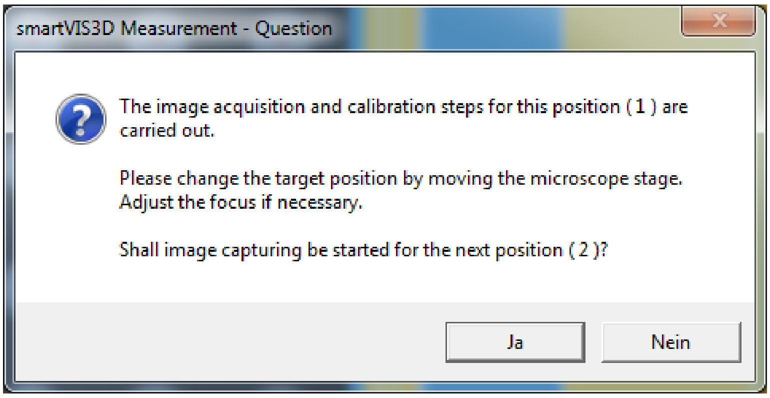



FIGURE 33: FIFTH INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

c. By clicking the "YES" button the second series of calibration measurements will be performed

d. Again if the calibration procedure was successful red crosses will appear in the center of the circles. After the second series of measurements is completed the dialog shown in Figure 34 will be automatically opened. In this dialog you will be notified that the second measurement series is completed. Additionally you will be asked again to change target's position using the x-y hand wheels of the microscopic stage to proceed with the third and last series of calibration measurements. Make sure again that conditions 8a and 8b are satisfied

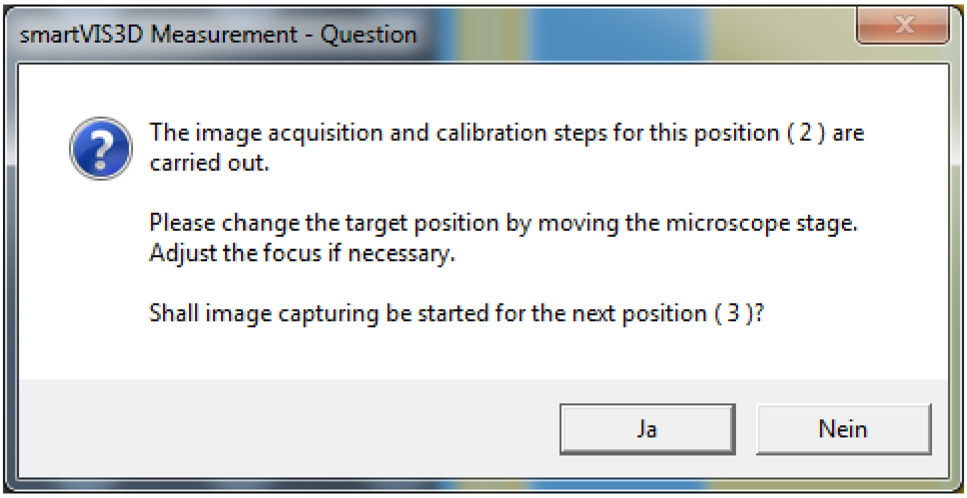



FIGURE 34: SIXTH INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

e. After the third and last series of calibration measurements are completed the dialog shown in Figure 35 will be automatically opened. In this dialog you will be notified that all required calibration measurements have been completed and that a new length scale corresponding to the selected objective and software settings has been determined, e.g. in Figure 35 the length scale value is approximately 0.00065 mm. If you want to apply the new length scale setting click the "YES" button, if not than the "NOT" button.

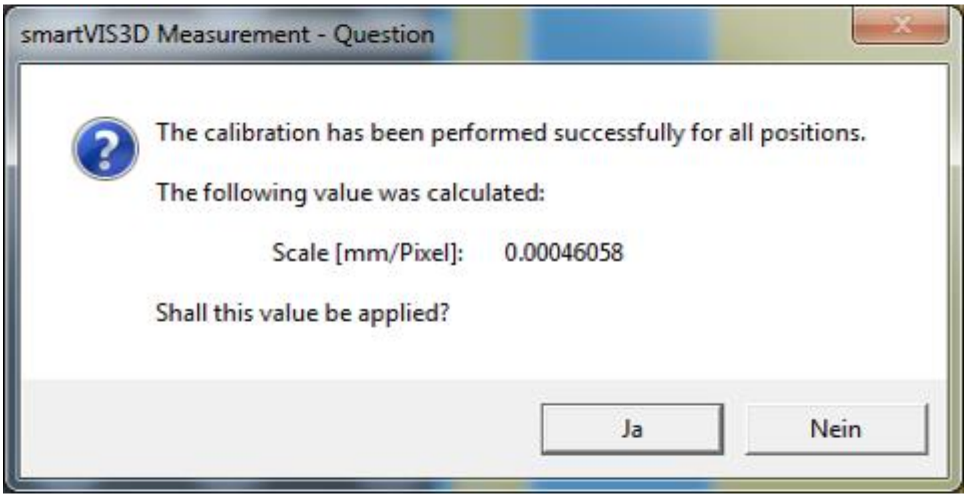



FIGURE 35: SEVENTH INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

f. After pressing the "YES" button the new length scale will be applied to software settings and the last instruction dialog, see Figure 36, will be shown in which you will be notified that the calibration process is completed. Press the "OK" button to close this dialog. After that the calibration procedure is completed

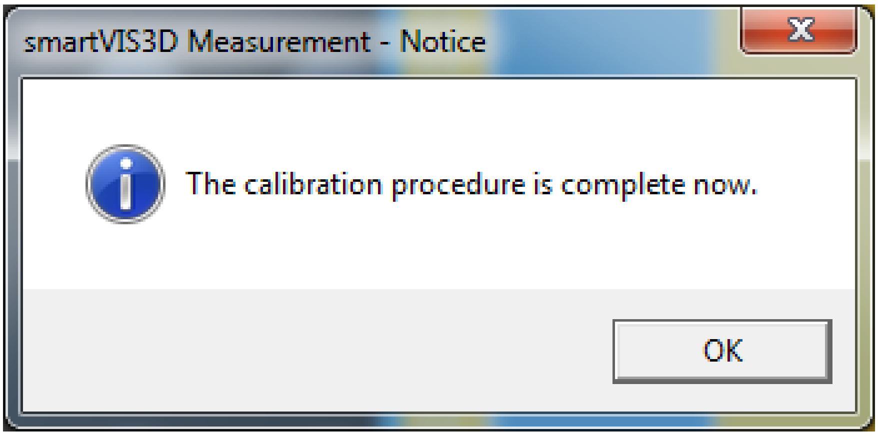



FIGURE 36: LAST INSTRUCTION DIALOG OF THE CALIBRATION PROCEDURE

# 3.8. Measurements in VSI mode

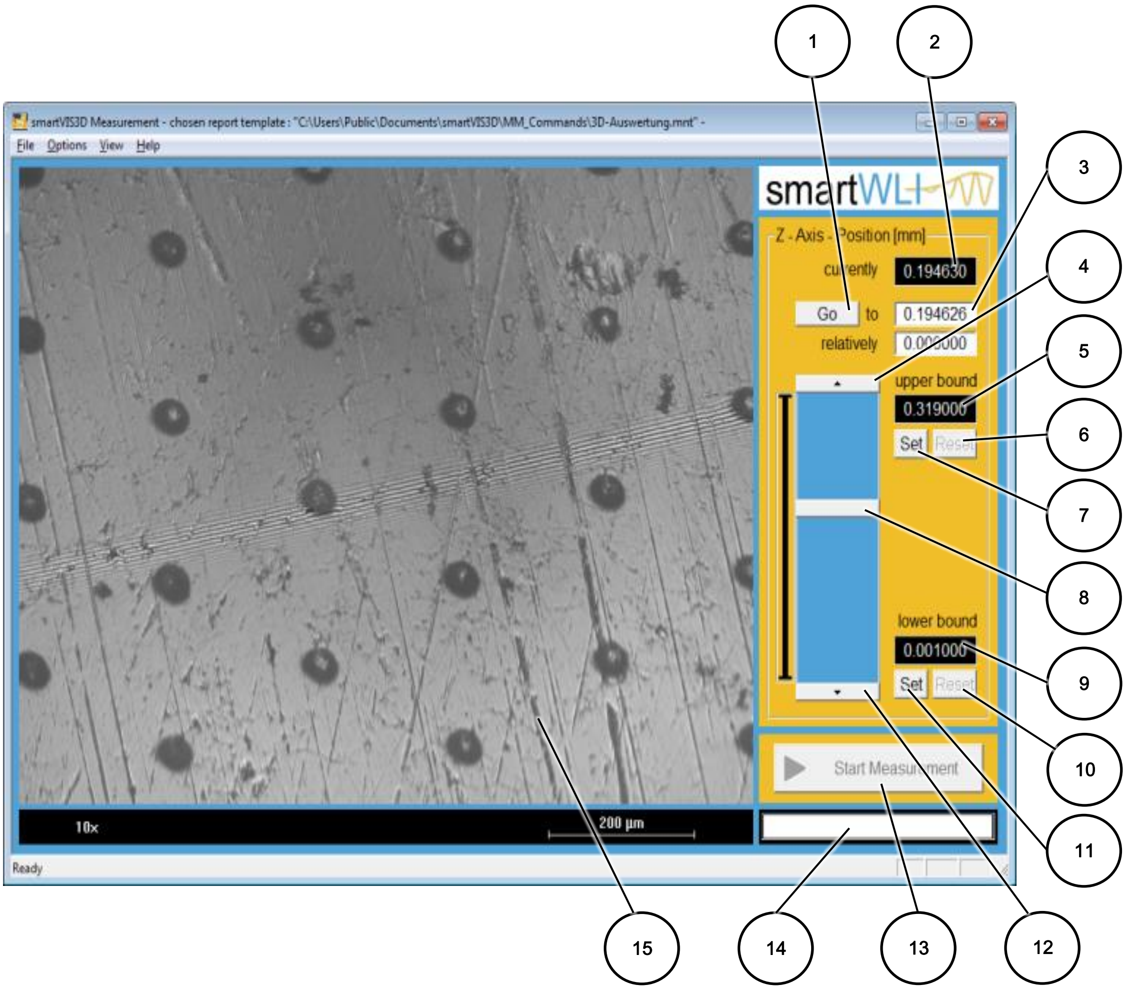
Before a measurement procedure is executed make sure that the following prerequisites are fulfilled:

- Read and follow the information on the correct usage of the measurement device described in the hardware manual of your measurement device
- Turn on the measurement system
- Read and comply with the instructions from section 3.2
- Place the specimen on the microscopic stage underneath the installed objective
- Set the illumination coarsely, see section 3.4 for information on how to adjust the illumination settings
- Select the VSI measurement mode in the “Measuring Options Menu”, see section 2.3.1 and the other settings necessary for your measurement task
- Leveling of the tilting stage has been performed as necessary (applies only for measurement devices equipped with a tilting stage)

Note: If the magnitude of the $R_a$ value is unknown it is recommended to choose the “Rough” setting initially. After the measurement procedure is completed the $R_a$ value can be determined using the analysis software MountainsMap®. If this value is below 200 nm then subsequent measurements can be repeated using the setting “Smooth” to achieve higher measurement accuracy.

## Measurement Procedure:

1. Set the z-position of the objective to the middle of the movement range of the piezo adjuster using the scrollbar (8) or the arrow buttons and above (4) and below (12) the scrollbar area. Default movement range of the piezo adjuster is 0.4 mm thus the value shown in the display field “Currently” (2) should be approximately 0.2 after adjusting the position of the objective as required. Alternatively the desired value can be entered in the input field (3) on the right of the “Go” button (1). By pressing the “Go” button (1) after the value was entered in the input field (3) the position of the scrollbar (8) as well as the value in the display field “Currently” (2) will be updated to the desired position and value respectively
2. Adjusting the z-position of the objective search for interference fringes in the live view image (15) until they appear in the center of the image




Note: The complete movement range of the piezo adjuster is only available in case no upper and lower scan range limits were set by the user

3. Move up the position of the objective using the scrollbar (8) or the arrow buttons (4) and (12) until the interference fringes are no longer visible in the live view image (15). Click on the "Set" button (7) for the upper scan range limit to set the upper bound in the measurement software to this value. In the display field for the upper bound (5) the shown value will be updated to the current z-position of the objective which is displayed in the "Currently" field (2). Furthermore to show that a user defined upper bound is set the background of the display field (5) will be set to blue. If you want to reset the upper scan range limit to its default value press on the "Reset" button (6). By doing so the value for the upper bound will be set to the maximum scan range value and the background color of the field (5) will be changed to black
4. After setting the upper bound using the scrollbar (8) or the arrow buttons (4) and (12) move the position of the objective down until the interference fringes appear and

disappear again. Click on the “Set” button (11) for the lower bound of the scan range to update the lower scan limit in the software. Like for the upper bound by pushing the “Set” button (11) the value in the display field (9) for the lower bound will be updated to the current z-position shown in display field (2) and the background color of the field (9) will be changed to blue. To reset the lower bound to the default value press the “Reset” button (10). By doing so the value for the lower bound will be set to the minimum scan range value and the background color of the field (9) will be changed to black

5. Check if the illumination settings have been set to a suitable magnitude, such that no yellow pixels which identify overexposed areas are present in the live view image. It isn’t possible to take any valid measurement from overexposed areas, which is why overexposure should be avoided. Change the illumination settings if necessary. After proper illumination settings have been selected you can proceed with the measurement by clicking on the “Start Measurement” button (13)
6. After pressing the “Start Measurement” button the measurement procedure will take place. The progress bar (14) will show the current status of the running measurement. During the measurement the live view shows captured images which are used in the computation process. Furthermore, all controls for manipulations of the z-position of the piezo adjuster will be disabled, such that the user cannot interfere with the measurement software
7. After the measurement is completed the measurement results will be sent automatically to the analysis software MountainsMap® and displayed graphically. During the measurement procedure disabled z-position control elements will be enabled again. If wished the measurement results can be saved in a desired format. Supported formats are listed in section 2.2

## 3.9. Measurements in PSI mode

Before a measurement procedure is executed make sure that the following prerequisites are fulfilled:

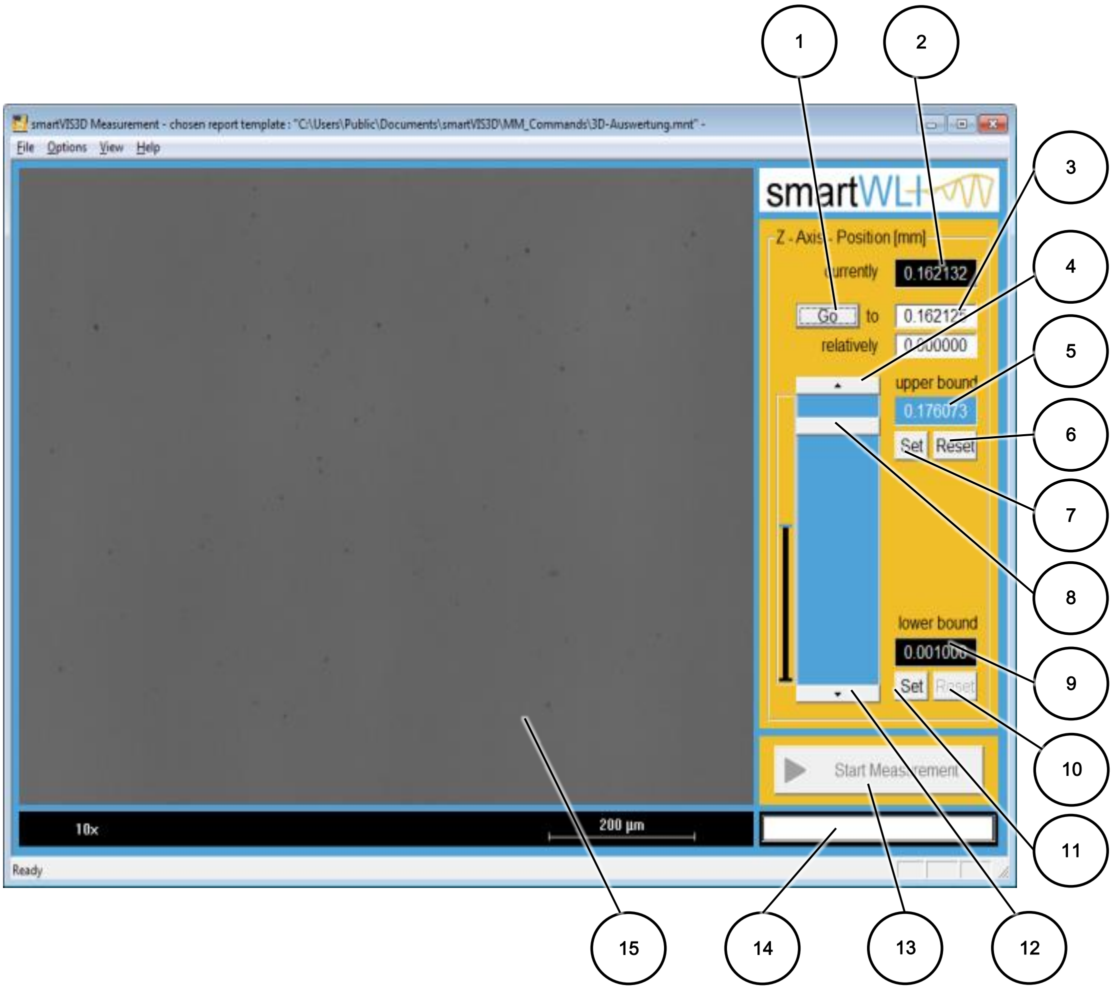
- Read and follow the information on the correct usage of the measurement device described in the hardware manual of your measurement device
- Turn on the measurement system
- Read and comply with the instructions from section 3.2
- Place the specimen with a smooth surface on the microscopic stage underneath the installed objective

- Set the illumination coarsely, see section 3.4 for information on how to adjust the illumination settings
- Select the VSI measurement mode in the “Measuring Options Menu”, see section 2.3.1 and the other settings necessary for your measurement task
- Leveling of the tilting stage has been performed as necessary (applies only for measurement devices equipped with a tilting stage)

Note: If the magnitude of the $R_a$ value is unknown it is recommended to choose the “Rough” setting initially. After the measurement procedure is completed the $R_a$ value can be determined using the analysis software MountainsMap®. If this value is below 200 nm then subsequent measurements can be repeated using the setting “Smooth” to achieve higher measurement accuracy.

## Measurement Procedure:

1. Set the z-position of the objective to the middle of the movement range of the piezo adjuster using the scrollbar (8) or the arrow buttons and above (4) and below (12) the scrollbar area. Default movement range of the piezo adjuster is 0.4 mm thus the value shown in the display field “Currently” (2) should be approximately 0.2 after adjusting the position of the objective as required. Alternatively the desired value can be entered in the input field (3) on the right of the “Go” button (1). By pressing the “Go” button (1) after the value was entered in the input field (3) the position of the scrollbar (8) as well as the value in the display field “Currently” (2) will be updated to the desired position and value respectively
2. Adjusting the z-position of the objective search for interference fringes in the live view image (15) until they appear in the center of the image
3. Adjust the angle of the tilting stage in such a way that the number of visible interference fringes in the live view image is as small as possible. However the visible fringes should span the entire view area
4. Move the position of the objective slightly up using the scrollbar (8) or the arrow button up (4) and click on the “Set” button (7) for the upper scan range limit. In the display field for the upper bound (5) the shown value will be updated to the current z-position of the objective which is displayed in the “Currently” field (2). Furthermore to show that a user defined upper bound is set the background of the display field (5) will be set to blue. If you want to reset the upper scan range limit to its default value press on the “Reset” button (6). By doing so the value for the upper bound will be set to the maximum scan range value and the background color of the field (5) will be changed to black




Note: The complete movement range of the piezo adjuster is only available in case no upper and lower scan range limits were set by the user

5. Move the position of the objective slightly down covering at least the double distance as before. Click on the “Set” button (11) for the lower bound of the scan range to update the lower scan limit in the software. Like for the upper bound by pushing the “Set” button (11) the value in the display field (9) for the lower bound will be updated to the current z-position shown in display field (2) and the background color of the field (9) will be changed to blue. To reset the lower bound to the default value press the “Reset” button (10). By doing so the value for the lower bound will be set to the minimum scan range value and the background color of the field (9) will be changed to black
6. Check if the illumination settings have been set to a suitable magnitude, such that no yellow pixels which identify overexposed areas are present in the live view image. It isn’t possible to take any valid measurement from overexposed areas, which is why overexposure should be avoided. Change the illumination settings if necessary

7. Move the scrollbar up in between of the upper and lower scan range limit. By pushing the “Start Measurement” button (13) the measurement procedure will begin. The progress bar (14) will show the current status of the running measurement. During the measurement the live view shows captured images which are used in the computation process. Furthermore, all controls for manipulations of the z-position of the piezo adjuster will be disabled, such that the user cannot interfere with the measurement software
8. After the measurement is completed the measurement results will be sent automatically to the analysis software MountainsMap® and displayed graphically. During the measurement procedure disabled z-position control elements will be enabled again. If wished the measurement results can be saved in a desired format. Supported formats are listed in section 2.2

# 4. Troubleshooting

| Error Message / Disruption | Possible cause | Possible Resolution |
|---|---|---|
| Application is already running | The smartVIS3D measurement software is already running or is currently active<br><br>Note: Only a single instance of the smartVIS3D software can be running at once | Quit the measurement software and wait a moment. Start the software again. If the error appear again but no smartVIS3D GUI is shown, use the Windows Task Manager to terminate the running smartVIS3D process |
| Camera error: No camera found | • The controller box is not switched on<br>• The Ethernet cable is not inserted correctly or is defective<br>• Instrument cable could be defective or is not inserted correctly | • Turn on the controller box<br>• Check the Ethernet cable<br>• Check the instrument cable<br>Note: Wait a moment (≥ 10 s) after switching on the controller box, as it requires some initialization time |
| Initialization: MIPOS-Error (getstat): 2 | • Incorrect COM port is used<br>• The USB cable is not inserted correctly | • Check the serial cable connection and whether it is connected to the correct USB port |
| Initialization: MIPOS-Error (open): 4 | • Configuration error, selected COM port does not exist | • Change the configuration file<br>• Contact the GBS mbH service team |
| • No image is visible<br>• A black or a blue image is shown (possible with some noise) | • Illumination is not turned on<br>• Control device is not connected to the power supply | • Switch on the illumination using the controls in the software<br>• Check whether the USB cable is connected |

# 5. List of Figures