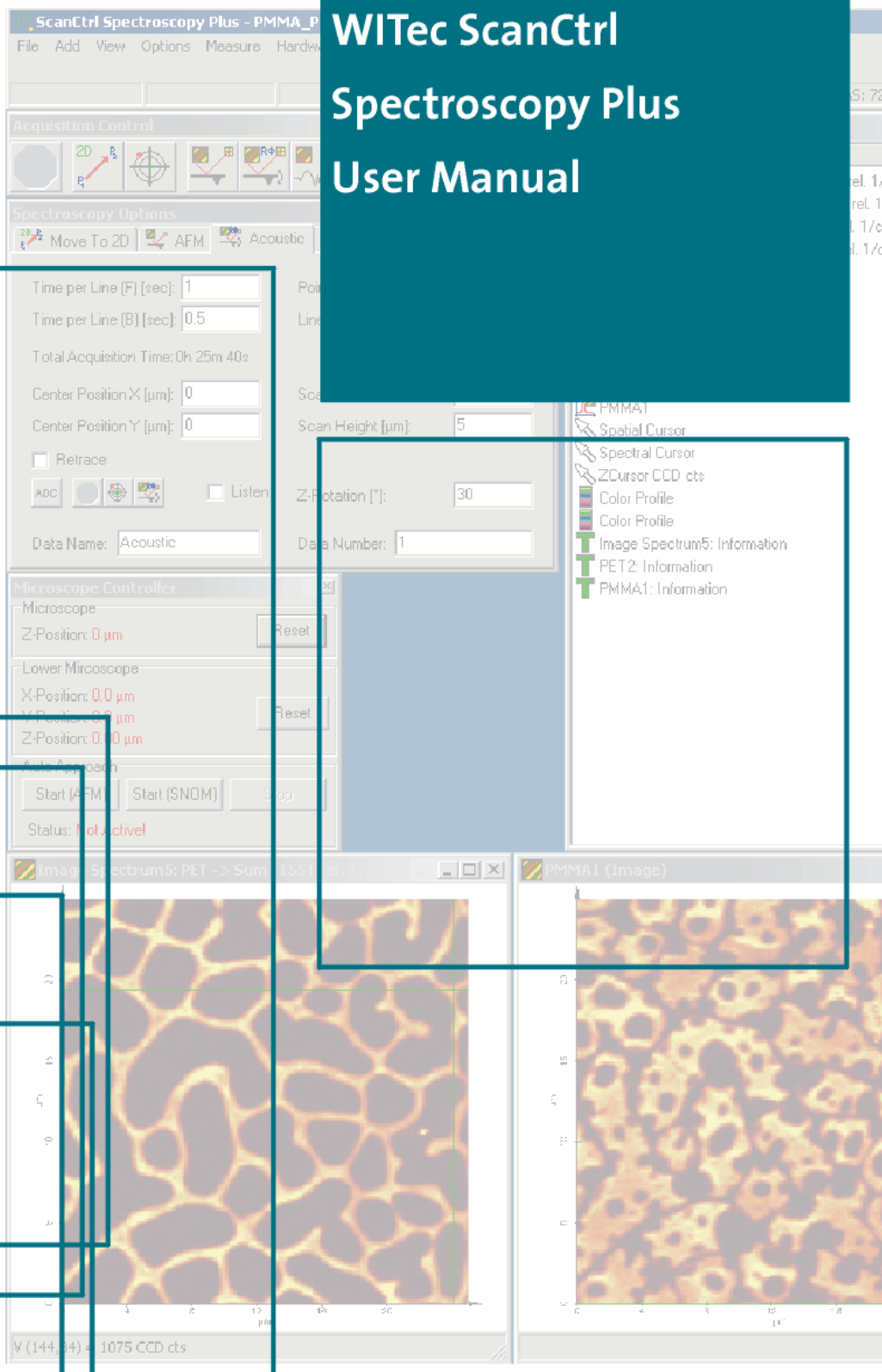
WITec ScanCtrl Spectroscopy Plus User Manual



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About this manual

This manual describes the ScanCtrl Spectroscopy Plus scanning and data acquisition software. ScanCtrl Spectroscopy Plus is based on the WITec Project software. It uses the structure and all the components of the WITec Project software with additional hardware functions for measuring modes such as Confocal Raman Microscopy, SNOM, and AFM. Only these modes of measurement and their corresponding Spectroscopy Options are described in this manual.
For information about all other features, the user is referred to the WITec Project manual.

Warnings are marked with a red bar. Please read these warnings carefully to avoid problems that may otherwise occur.

HINT Throughout the manual, you will find text blocks with a blue **HINT** on the left–hand side of the text. These text blocks contain additional, useful information.

Text parts such as Menu Item Name refer to a menu item of the software.

Text parts such as Button Name refer to a button or checkbox of the software.

Keyboard keys are highlighted as Key.

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Safety Information

This software controls the hardware of WITec Microscopes. Please read this manual carefully before using the software. Reading the system description of the Microscope and the corresponding operation manual before starting any measurement is also recommended.

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Chapter 1

Appearance

After opening the ScanCtrl Spectroscopy Plus software, the main window is displayed. The main menu of the ScanCtrl Spectroscopy Plus software provides access to all functions and menus. All functions can be accessed using either a mouse or via HotKeys using the Alt - key on your keyboard in combination with the appropriate letter for the desired menu.
While almost identical to the WITec Project software, two additional functions appear in the main menu. The new functions are described below. For a detailed description of all other functions, the user is referred to the WITec Project manual.

1.1 Hardware Options

All hardware options are listed in this menu. As the available hardware options depend on the configuration of the system, not all described options may apply to your system.

1.1.1 Spectroscopy Options

This menu opens the spectroscopy options window. In this window, the imaging and spectroscopy modes are listed as tab sheets.

HINT Each tab sheet contains the scan control capabilities required for the imaging and spectroscopy modes.

A detailed description of the imaging and spectroscopy modes can be found in Chapter 4.

1.1.2 CCD Settings

The settings of the CCD camera (if applicable) are available through the CCD settings window. This function is only available if the WITec microscope is equipped

with a spectroscopy setup. A detailed description is given in Section 2.3.

1.1.3 Spectrograph

The hardware settings of the spectrograph are shown in the spectrograph window. It is only available for WITec microscopes equipped with a spectrograph. A detailed description is given in Section 2.4.1.

1.1.4 Microscope Controller

This function opens the microscope controller window. This window contains general functions related to the controller. For the various microscopy techniques, different microscope control windows are displayed. A detailed description can be found in Section 2.2.

1.1.5 Method

In this submenu, the microscope's mode of operation can be selected. The software will list only the microscope operation modes corresponding to the system configuration. When selecting the proper microscope operation method e.g. AFM, SNOM, Raman, or Confocal, the software will display the available measuring modes. The spectroscopy options window, acquisition control, and measure menu will change accordingly. The current method is displayed in the status bar of the main menu.

1.2 Measure

This menu provides access to the various modes of measurement. This menu allows the user to start and stop measurements, adjust signals, move the sample, and cool the CCD camera for spectroscopy. The first item shows or hides the acquisition control window, which provides quick access to the functions listed above.

HINT These menu items will change depending on the selected microscopy method.

Chapter 2

Hardware Control

The hardware components included with WITec microscopy systems depend on individual configurations. The ScanCtrl Spectroscopy Plus software uses different windows for various functionalities and hardware configurations, therefore, the appearance of some windows may differ depending on the specific setup.
A description of these hardware configurations and windows is given in this chapter. All required software windows open from the main menu of the ScanCtrl Spectroscopy Plus software under the menu item Hardware Options (Section 1.1).

2.1 AD/DA Data Acquisition Board

ScanCtrl Spectroscopy Plus uses a PCI data acquisition board. This hardware component is not associated with any window. The card has 16 bit A/D and D/A resolution at very high conversion rates (250 kHz sampling rate). Two analog output and eight differential input channels are used for scan control and data acquisition.

Output Channels

The output channels X and Y control the movement of the scan table by delivering a 16 bit analog output voltage (0-10 V). This voltage is amplified in the LVPZT-amplifier module connected to the scan table.

Input Channels

Up to 8 input channels with 16 bit resolution are used for external signal acquisition. Eight signals such as: topography, T-B (deflection), L-R (friction), light intensity, etc. can be acquired simultaneously during a scan. These inputs are labelled as channels 1-8. The input range depends on the selected gain. If the gain is equal to one, the input range is -10 to 10 volts. The gain can be changed separately for every input channel (see Section 3.2.1).

Digital Outputs

Three digital outputs labelled as Pixel Trigger, Line Trigger, and Image Trigger

can be used to control or synchronize external devices (such as spectrographs, CCD cameras, etc.) with the scan.

2.2 Microscope Controller

The microscope controller window contains various functions according to the microscope setup. The microscope controller window is shown in Fig. 2.1. The various components of the system together with their control requirements are listed in this window. All functions belonging to one hardware component are marked with a group box.

HINT Your system might not have all the listed hardware components, therefore, some function group boxes may be unavailable.

A detailed description of the functions, parameters, and switches shown in Fig. 2.1 is given below.

Microscope Stage

In this part of the microscope control window, the z-position of the microscope is displayed. After starting ScanCtrl Spectroscopy Plus, the z-position display will show $0\ \mu m$. Up and down movements of the microscope stage will increase or reduce this value. The Reset button sets the z-position value to zero. In addition, the new z-origin for the coordinate system (see Section 3.1.1) is set to zero. A manual movement with the remote control changes the displayed z-position. This move does not affect the z-position of the coordinate system in the software. For more details, see Section 3.1.1.

Lower Microscope Stage

The AlphaSNOM incorporates a microscope underneath the sample stage to collect the transmitted light. Movement of the microscope in the x, y, and z directions is used to align it with the upper optical axis. In this part of the microscope controller window, the x-, y-, and z-position of the lower microscope is displayed. After starting ScanCtrl Spectroscopy Plus, the x-, y-, and z-positions will read $0\ \mu m$. Movements of the lower microscope will be displayed as positive or negative values. The Reset button sets all values to zero.

APD

This group box shows the current state of the APD (if available) and allows the user to turn it ON or OFF.

PMT

This group box shows the current state of the PMT (if available) and allows the user to turn it ON or OFF.

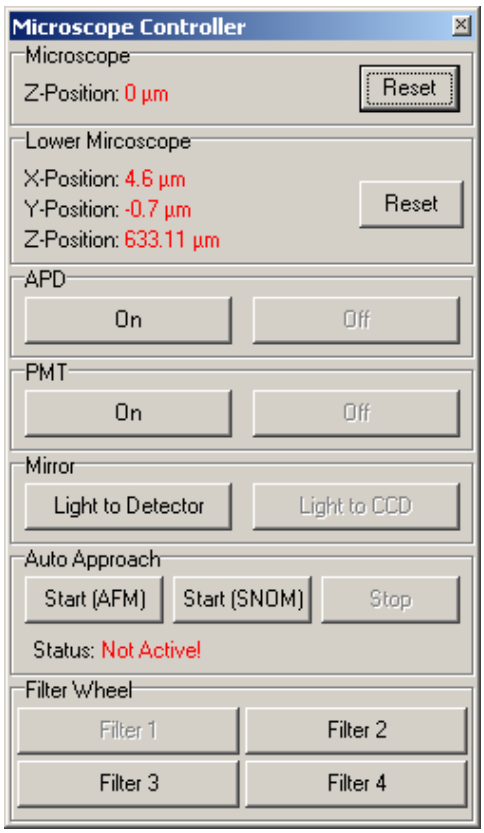

Fig. 2.1: Microscope Controller Window.

Mirror

The light collected with the lower microscope can be detected with the corresponding detector (PMT, APD) or observed with a CCD camera.

HINT The group boxes: APD, PMT, Mirror are control relays in the microscope controller. In customized systems, these group boxes change their functionality. They may also be used for turning ON/OFF lasers or other detectors.

Auto Approach

This controller function is used to automatically approach the sample with the AFM or SNOM cantilever. The Start (AFM) and Start (SNOM) buttons will lower the upper microscope until the setpoint for the feedback loop is met and the scan table reaches its final position. The Stop button stops the automatic approach. The status of the auto approach is shown in red.

In case of Start (SNOM), the lower microscope (used for transmission measurements in SNOM mode) will move synchronously with the upper microscope's approach.

Filter Wheel

If the system is equipped with a filter wheel in the transmitted beam path, the filter position can be changed by selecting Filter 1-4.

2.3 CCD Control

The tab sheets of the CCD settings window are used to control hardware settings and the temperature of the CCD camera. The tab sheets temperature, speed, and information are described as follows:

Temperature

In this tab sheet, the status of the CCD camera cooler is displayed. In the edit box Target Temperature the temperature of the camera can be set. The label below displays the actual temperature of the CCD.
The cooler of the CCD can be turned ON and OFF using the buttons Cooler On and Cooler Off. The label of the current temperature changes color: black $\equiv$ cooler OFF, red $\equiv$ un-stabilized temperature, green $\equiv$ stabilized temperature. This information is displayed in the status bar of the main window of ScanCtrl Spectroscopy Plus. An example of this tab sheet is shown in Fig. 2.2.

To avoid stress on the CCD chip it is important to warm up the CCD camera under computer control. The temperature of the CCD camera should be higher than $0\,^{\circ}C$ before the software is closed.

Speed

The Speed tab sheet allows the user to change the horizontal and vertical shift speed for the readout process of the CCD camera. An example is shown in Fig. 2.3.

Information

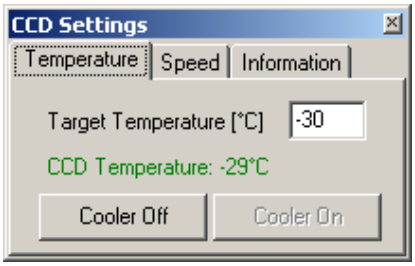

Fig. 2.2: Temperature tab sheet of the CCD settings window.

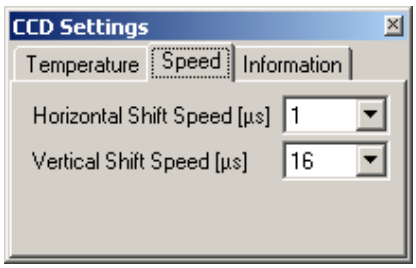

Fig. 2.3: Speed tab sheet of the CCD settings window.

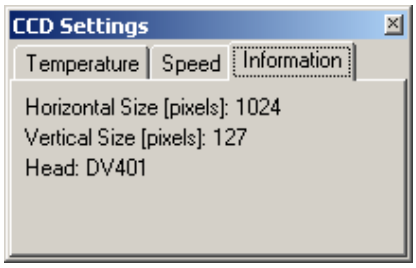

Fig. 2.4: Information tab sheet of the CCD settings window.

The information tab sheet contains information about the size of the pixel array and the model of the camera used. An example is shown in Fig. 2.4.

2.4 Spectrograph and Calibration

This section describes how to control and calibrate the spectrograph.

2.4.1 Spectrograph

The spectrograph window is shown in Fig. 2.5. The top line contains speed buttons for the following functions:

Move 

Moves the selected grating of the spectrograph to the spectral center. This spectral position will be centered on the CCD camera or the APD detector.

CCD 

Switches the mirror in the spectrograph from the APD exit to the CCD exit.

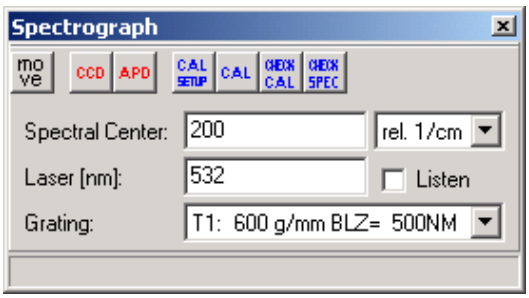

Fig. 2.5: Spectrograph Control Window.

APD 

Switches the mirror in the spectrograph from the CCD exit to the APD exit.

Calibration Setup 

Opens the window containing calibration options for the spectrograph (see Section 2.4.3).

Calibration 

Starts and stops an automatic calibration routine for the selected grating (see Section 2.4.2).

Check Calibration 

Checks the current calibration parameters. A report is shown in a text data object (see Section 2.4.2). Pressing this button for a second time will abort the routine.

Check Spectrograph 

Checks the internal calibration of the spectrograph (see Section 2.4.2). Pressing this button for a second time will abort the routine.

The panel below contains information about and settings for the spectrograph:

Spectral Center

This box allows the user to select the spectral center. The units can be changed using the scroll window. After changing this value, the move button must be activated to move the grating to the new center. Using the listen button, the user can select a center position from a spectrum.

Laser

The laser wavelength can be changed. The system requires this information as a reference for the appropriate calculation of units such as rel. 1/cm.

Grating

The scroll window next to this description allows the user to select from among the gratings installed in the spectrograph.

2.4.2 Calibration Routines

For all calibration routines, an appropriate calibration source is required and must be connected to the spectrograph entrance. The focus spectrum integration time should be set to the smallest possible value. Now press the focus spectrum button  and adjust the intensity of the calibration peaks into the range of 100 cts to 30000 cts. After starting one of the calibration routines, the integration time is automatically adjusted in order to obtain a peak intensity of 10000 cts or more. The calibration routine is performed with the currently used grating. Focus Spectrum must run until the calibration routine has finished and created its report.
The following section describes the calibration routines: Check Spectrograph, Check Calibration, and the Calibration itself. Each routine uses its own set of wavelengths (see Section 2.4.3).

Check Spectrograph

The spectrograph itself is only calibrated on its optical axis. This calibration is performed at WITec and stored in the hardware of the spectrograph. The check spectrograph routine  verifies this on-axis calibration. A report of this calibration is added to the current project as a text data object.

```
Found Center (0 nm) at Pixel:  510.27
Found Center (404.656 nm) at Pixel:  510.06 Error:  -0.21
Found Center (435.833 nm) at Pixel:  510.17 Error:  -0.10
Found Center (546.074 nm) at Pixel:  510.13 Error:  -0.14
Found Center (696.543 nm) at Pixel:  509.87 Error:  -0.40
Found Center (912.297 nm) at Pixel:  509.88 Error:  -0.39
```

To begin the check spectrograph routine, the current grating is moved to the 0 nm position (zeroth-order). The found peak position is used as a reference. The grating is then moved to all other wavelengths selected for this calibration routine. Their peak positions should always be at the same pixel position. If the displacement (error) between the reference and found positions is larger than 5 pixels, the routine will abort. If this check fails, please contact your WITec support team.

Check Calibration

The check calibration routine  makes a verification of the off-axis calibration. A report of this verification is added to the current project as a text data object.

```
                                    ⋮
Mercury:  404.656 nm
Pixel:  994.04 Error:  -0.03 Error:  -0.014 nm
Pixel:  753.18 Error:   0.12 Error:   0.069 nm
Pixel:  512.06 Error:  -0.08 Error:  -0.047 nm
Pixel:  271.02 Error:  -0.07 Error:  -0.040 nm
Pixel:   30.05 Error:   0.04 Error:   0.024 nm
Maximum Error:  0.069 nm
Average Error:  0.039 nm
                                    ⋮
Argon:  696.543 nm
Pixel:  993.82 Error:  -0.24 Error:  -0.129 nm
Pixel:  753.06 Error:   0.02 Error:   0.010 nm
Pixel:  511.87 Error:  -0.27 Error:  -0.146 nm
Pixel:  270.87 Error:  -0.24 Error:  -0.130 nm
Pixel:   30.09 Error:   0.01 Error:   0.008 nm
Maximum Error:  0.146 nm
Average Error:  0.085 nm
                                    ⋮
Argon:  912.297 nm
Pixel:  993.82 Error:  -0.29 Error:  -0.156 nm
Pixel:  752.85 Error:  -0.27 Error:  -0.146 nm
Pixel:  511.77 Error:  -0.29 Error:  -0.160 nm
Pixel:  270.84 Error:  -0.06 Error:  -0.031 nm
Pixel:   30.57 Error:   0.46 Error:   0.251 nm
Maximum Error:  0.251 nm
Average Error:  0.149 nm
                                    ⋮
Total Maximum Error:  0.251 nm
Total Average Error:  0.085 nm
```

To begin the check calibration routine, the check spectrograph routine is performed. After this, the grating is moved in such a way that the selected peaks for this calibration routine move from one side of the CCD to the other. The number of test positions can be changed in the calibration options window (see Section 2.4.3).
The wavelength of the peak position is measured and compared with the desired wavelength. The report shows the found peak positions, the error for each selected wavelength, and position on the CCD. The average error and maximum error is also reported for each selected wavelength.

Calibration

The calibration routine calibrates the off-axis parameter of the current grating. A report of this calibration is added to the current project as a text data object.

```
                                    ⋮
Focus:    297.61
Gamma:     31.30
Delta:     -3.97
CenterN: 509.98
                                    ⋮
```

Before the automatic off-axis calibration routine starts, the check spectrograph routine is performed. After this, the grating is moved in such a way that the selected peaks for this calibration routine move from one side of the CCD to the other. The number of test positions can be changed in the calibration options window (see Section 2.4.3).
The peak positions, the on-axis wavelength, and the wavelength itself are stored for each selected wavelength. This data is used to calculate the calibration parameters.
At the end of this routine, the check calibration routine is started in order to verify the new calibration.

2.4.3 Calibration Options

The parameters and wavelengths used for the check spectrograph, check calibration, and calibration routine can be changed in the calibration options dialog. Pressing the CAL SETUP button in the spectrograph window opens the dialog shown in Fig. 2.6.

Number of Test Positions

The number of test positions is used in the check calibration and calibration routines. In order to collect data for the calibration or to verify the calibration, each emission line is scanned across the CCD. This parameter changes the number of scans.

Short Report

This check box reduces the length of the Report, which is displayed at the end of all calibration routines.

List of Emission Lines

The list view shows all emission lines. The columns show the name of the emission line, the wavelength of the emission Line, the search range, and the usage for the emission line.
The search range is used for the automatic peak detection in all calibration routines. The usage parameter defines the affiliation to a calibration routine. If an entry is selected by mouse, the parameters of this emission line will be copied to the edit boxes above the list view.

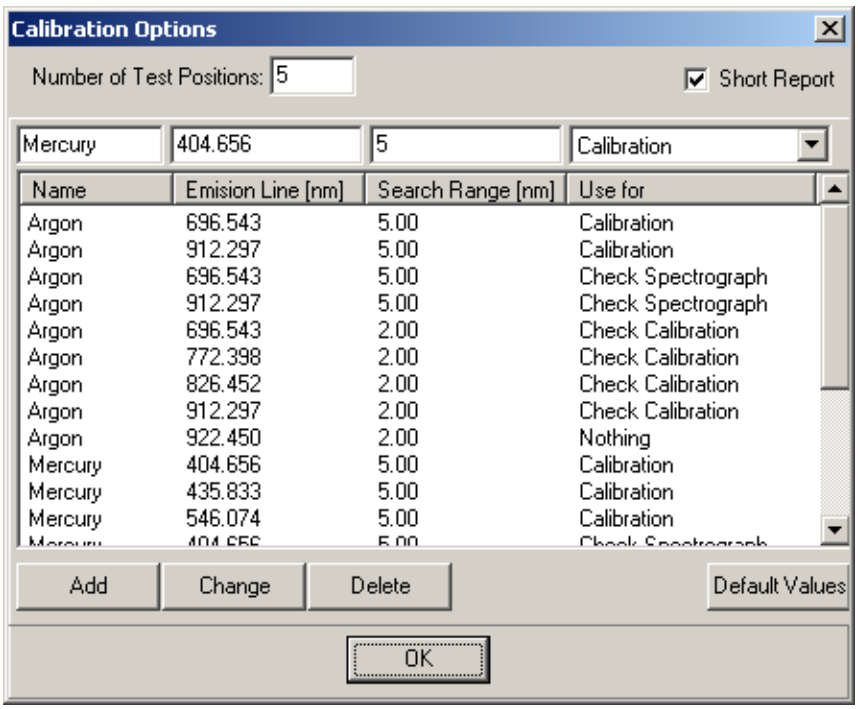

Fig. 2.6: Calibration Options window. These options are used for the calibration routines.

Add

The Add button adds a new emission line to the list. The parameters for this entry can be defined in the edit boxes above the list view.

Change

The Change button changes the selected emission line entry. The new parameters can be defined in the edit boxes above the list view.

Delete

The Delete button deletes the selected emission line entry.

Default

The Default button sets all emission line entries and parameters to default values.

Chapter 3

Operating Principle

This chapter explains how the software moves the sample and collects data. The different scan modes and their parameters are introduced in the first section.
The second section describes how up to 8 different signals can be measured synchronously with the sample movement. The third section explains all spectroscopy modes and their parameters.

3.1 Sample Movement and Scanning

This section describes how the sample is moved during the various acquisition modes. To keep different measurements comparable, the ScanCtrl Spectroscopy Plus software uses the same coordinate system for all acquisition modes. For this purpose, an absolute coordinate system is introduced.
All parameters that control the sample movement are explained in this section. They will appear in various tab sheets in the spectroscopy options window.
To prevent unintentional movement in the z-direction by the software, some acquisition modes move in only two dimensions. This applies to all AFM and SNOM acquisition modes. In this case, the z-position is set to zero.

3.1.1 Coordinate System

ScanCTRL Spectroscopy Plus uses an absolute coordinate system. With respect to the x- and y-axes, the origin of this coordinate system is defined by the middle position of the piezo scan stage.
The z-origin is user-definable, depending on the position of the microscope stage (stepper motor). After starting the software and opening the microscope controller window (see Section 2.2), the z-origin of the microscope stage is set to $0\ \mu m$. Moving the microscope stage up or down will display the new z-coordinate with respect to the first position. Pressing the Reset button for the z-position will set the origin of the z-coordinate and reset the position counter for the microscope stage. This z-coordinate will be used as the internal reference for further measurements.

As long as the z-coordinate is not reset, the sample is not removed from the piezo-scanner, and the microscope stage is not moved manually, the system will use the same coordinate system for all available microscopy methods. This allows the user to perform various measurements at different positions on the sample.

3.1.2 Single Position

Several acquisition modes move the sample to a single position before the actual measurement starts. The time for this movement is set by WITec to an appropriate value for this acquisition mode. The position is set by the following parameters:

Position X
: Position X defines the x-coordinate in the absolute coordinate system for the next measurement. It must be set in μm.

Position Y
: Position Z defines the y-coordinate in the absolute coordinate system for the next measurement. It must be set in μm.

Position Z
: Position Z defines the z-coordinate in the absolute coordinate system for the next measurement. It must be set in μm.

Instead of setting these values with the keyboard, it is possible to set the position with a mouse click on an image or graph viewer. In this case, the Listen check box must be activated.

3.1.3 Line Scan

Some acquisition modes collect data along a line. Before the actual measurement starts, the sample is moved to the start position. The time for this movement is set by WITec to an appropriate value for this acquisition mode. After moving to the start position, data is collected along the straight line between the start and end positions. The time required to scan this line depends on the user definable integration time and number of acquisition steps. The start and end positions are set by the following parameters:

Start X
: Start X defines the x-coordinate in the absolute coordinate system for the start position. It must be set in μm.

Start Y
: Start Y defines the y-coordinate in the absolute coordinate system for the start position. It must be set in μm.

Start Z

Start Z defines the z-coordinate in the absolute coordinate system for the start position. It must be set in μm.

End X

End X defines the x-coordinate in the absolute coordinate system for the end position. It must be set in μm.

End Y

End Y defines the y-coordinate in the absolute coordinate system for the end position. It must be set in μm.

End Z

End Z defines the z-coordinate in the absolute coordinate system for the end position. It must be set in μm.

Instead of setting these values with the keyboard, it is possible to set the start and end positions with a mouse click on an image or graph viewer. In this case, the appropriate Listen check box must be activated.

3.1.4 Single Image Scan

A single image scan is a two-dimensional rectangular scan in the xy-plane of the absolute coordinate system. The z-position is user-definable but stays constant during the scan.
Before the actual measurement starts, the sample is moved to the upper left corner of the scan rectangle. The time for this movement is set by WITec to an appropriate value for this acquisition mode. After moving to the start position, the scan is performed line by line. Each line is scanned in the forward and backward directions. The acquisition mode determines if both directions can be used for data collection. The forward and backward scan speeds can be independently set. In some acquisition modes, the backward scan speed is set by the software to an appropriate value. The number of data points per line, the number of lines per image, and the size of the rectangle can be set independently. A single image scan is controlled by the following parameters. Not all parameters are available in each acquisition mode. Only one parameter of a redundant set of parameters is used in one acquisition mode. If a parameter is missing in an acquisition mode, it is set by the software to an appropriate value.

Center Position X

With center position x, the center of the rectangular scan can be defined. It must be set in μm.

Center Position Y

With center position y, the center of the rectangular scan can be defined. It must be set in μm.

Center Position Z

With center position z, the scan position can be set with respect to the z-coordinate. It must be set in μm.

Scan Width

Scan width sets the size of the rectangular scan. It is always the size of the fast scan direction (length of one line). It must be set in μm.

Scan Height

Scan height sets the size of the rectangular scan. It is always the size of the slow scan direction (height of the rectangular). It must be set in μm.

Z-Rotation

The scan rectangle can be rotated around its center. The rotation angle defines the rotation about the z-axis and must be set in degrees.

Integration Time (F)

One line is divided into several pixels (**Points per Line**). The integration time is the time for one pixel, data point, or spectrum. The acquisition mode always measures light intensities and this parameter is used for speed control in the forward direction. This parameter must be set in s.

Time per Line (F)

Time per line (F) controls the scan speed in the forward direction. It must be set in s.

Time per Line (B)

Time per line (B) controls the scan speed in the backward direction. It must be set in s.

Points per Line

Points per line allows the user to change the number of pixels, data points or spectra per line.

Lines per Image

Lines per image allows the user to select the number of lines scanned inside the rectangle.

Retrace

If data collection is necessary in the backward scan direction, the retrace parameter can be activated.

Instead of setting the center position values with the keyboard, it is possible to set them with a mouse click on an image or graph viewer. In this case, the appropriate Listen check box must be activated.
To set the center position and the scan size via mouse, the marker mouse mode of an image viewer can be used.

3.1.5 Depth Scan

A depth scan is a two-dimensional rectangular scan with the fast scan axis inside the xy-plane and the slow scan axis in the z-direction of the absolute coordinate system.
Before the actual measurement starts, the sample is moved to the upper left corner of the scan range. The time for this movement is set by WITec to an appropriate value for this acquisition mode. After moving to the start position, the scan is performed line by line. Each line is scanned in the forward and backward directions. Before the next line is scanned, the z-position is adjusted to the next value. The slow scan position always reduces the z-value. The backward scan speed is set by the software to an appropriate value.
The number of data points per line, the number of lines per image, and the size of the rectangle can be set independently. A depth scan is controlled by the following parameters. Not all parameters are available in each acquisition mode. Only one parameter of a redundant set of parameters is used in one acquisition mode. If a parameter is missing in an acquisition mode, it is set by the software to an appropriate value.

Center Position X

With center position x, the center of the rectangular scan can be defined. It must be set in μm.

Center Position Y

With center position y, the center of the rectangular scan can be defined. It must be set in μm.

Center Position Z

With center position z, the center of the rectangular scan can be defined. It must be set in μm.

Scan Width

Scan width sets the size of the rectangular scan. It is always the size of the fast scan direction (length of one line). It must be set in μm.

Scan Depth

Scan depth sets the size of the rectangular scan. It is always the size of the slow scan direction (height of the rectangular). It must be set in μm.

Z-Rotation

The scan rectangle can be rotated around its center. The rotation angle defines the rotation about the z-axis and must be set in degrees.

Integration Time

One line is divided into several pixels (**Points per Line**). The integration time is the time for one pixel, data point, or spectrum. The acquisition mode always measures light intensities and this parameter is used for speed control in the forward direction. This parameter must be set in s.

Points per Line

Points per line allows the user to change the number of pixels, data points, or spectra per line.

Lines per Image

Lines per image allows the user to select the number of lines scanned inside the rectangle.

Instead of setting the center position values with the keyboard, it is possible to set them with a mouse click on an image or graph viewer. In this case, the appropriate Listen check box must be activated.
To set the center position and the scan size via mouse, the marker mouse mode of an image viewer can be used.

3.1.6 Image Stack Scan

An image stack scan is a three-dimensional scan of the sample. This scan Volume is surveyed by several single image scans in the xy-plane (see Section 3.1.4). The z-position of the next image is automatically set by the software.
Before the actual measurement starts, the sample is moved to the start position of the 3-dimensional scan. The time for this movement is set by WITec to an appropriate value for this acquisition mode. After moving to the start position, the scan is performed line by line. Each line is scanned in the forward and backward directions. The backward scan speed is set by the software to an appropriate value.
The number of data points per line, the number of lines per image, the number of images, and the size of the box can be set independently. An image stack scan is controlled by the following parameters. Not all parameters are available in each acquisition mode. Only one parameter of a redundant set of parameters is used in

one acquisition mode. If a parameter is missing in an acquisition mode, it is set by the software to an appropriate value.

Center Position X

With center position x, the center of the box scan can be defined. It must be set in μm.

Center Position Y

With center position y, the center of the box scan can be defined. It must be set in μm.

Center Position Z

With center position z, the center of the box scan can be defined. It must be set in μm.

Scan Width

Scan width sets the size of the box scan. It is always the size of the fast scan direction (length of one line). It must be set in μm.

Scan Height

Scan height sets the size of the box scan. It is always the size of the slow scan direction (height of the rectangular). It must be set in μm.

Scan Depth

Scan depth sets the size of the box scan. Together with the number of images, it controls the distance between the images. It must be set in μm.

Z-Rotation

The scan rectangle can be rotated around its center. The rotation angle defines the rotation about the z-axis and must be set in degrees.

Integration Time

One line is divided into several pixels (**Points per Line**). The integration time is the time for one pixel, data point, or spectrum. The acquisition mode always measures light intensities and this parameter is used for speed control in the forward direction. This parameter must be set in s.

Points per Line

Points per line allows the user to change the number of pixels, data points, or spectra per line.

Lines per Image

Lines per image allows the user to select the number of lines scanned for one image.

Number of Images

Number of images allows the user to select the number of images scanned inside the box.

Instead of setting the center position values with the keyboard, it is possible to set them with a mouse click on an image or graph viewer. In this case, the appropriate Listen check box must be activated.
To set the center position and the scan size via mouse, the marker mouse mode of an image viewer can be used.

3.2 Data Acquisition

This section describes the analog data acquisition features of the software. Up to 8 different signals can be measured at the same time. The acquisition mode determines if this data acquisition is enabled. Each acquisition mode has its own channel window. In this channel window, the user can set which channels should be measured, how the analog signals are interpreted, and if the data should be displayed automatically.
To open this channel window for an acquisition mode, press the ADC button in the corresponding tab sheet of the spectroscopy options window.

3.2.1 Channels Window

Fig. 3.1 shows the channels window. The title of the window contains the name of the acquisition mode to which these channel selections apply. In the first line, the names of the parameters are listed. The table below allows these parameters to be changed for each channel. The following section will explain their functions:

Number

In this column, the available data acquisition channels are listed. The channel number corresponds to the input channels on the connector board of the controller.

Acquire

This column contains check boxes that determine which channels will be acquired. With the settings shown in Fig. 3.1, the input data of channel 1 and 5 will be acquired.

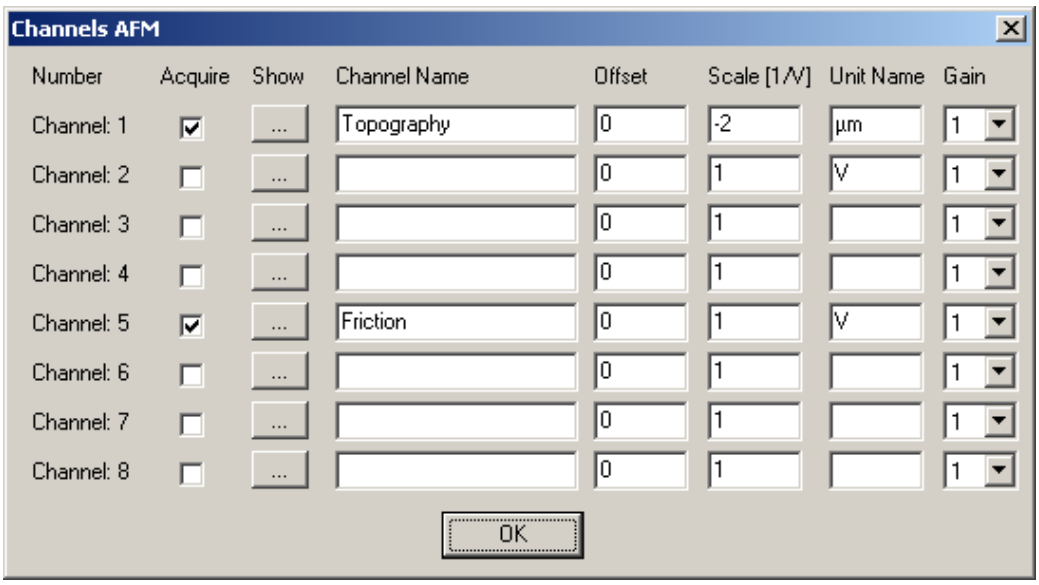

Fig. 3.1: Data Acquisition Channels.

Show

For every channel, a selection of online display possibilities is available. Clicking with the left mouse button on the corresponding button will open this dialog. Please see Section 3.2.2 for more information.

Channel Name

In this column, the user can enter a name for every channel. This name will be saved in the data caption.

Offset

In this column, an offset correction for the acquired data in the corresponding channel can be performed. The unit of this offset correction is the same as the unit name, which is explained below.

Scale [1/V]

All acquired signals are measured in Volts. A scale factor can be used to display the data in the correct units. The voltage range for the analog inputs is ± 10 V.

Unit Name

In this column, the unit of the measured signal can be entered. This unit will be saved in the z-interpretation data object and displayed in the associated cursor viewer.

Gain

This feature enhances the accuracy of the data acquisition. When choosing a gain other than 1, the 16Bit resolution remains, but the input voltage range of the card will be reduced. The input signal is multiplied by the chosen gain factor before it is read by the data acquisition board. Thus choosing a Gain of 4 will reduce the input range from ±10 V to ± 2.5 V. Therefore the Least Significant Bit will represent 76 μV instead of 304 μV and the sensitivity will increase accordingly.

3.2.2 Show Options

Fig. 3.2 shows the show options dialog. It can be opened by pressing on the show button in the channels window (see Section 3.2.1). The show options window is divided into three parts:

Image

This section defines how an image is displayed in an image viewer after the acquisition starts. On the upper left side, the user can choose whether or not the image will be displayed in an image viewer during the measurement. Checking Show Forward will open a viewer for the forward scan image. Checking Show Backward will open a viewer for the backward scan image. If both boxes are checked, both image viewers will open after starting a scan. Camera Phi and Camera Theta allow the user to display the images under various pitch angles. The values for phi and theta in Fig. 3.2 correspond to a top view display of the image.

The Line Correction function contains tools to change the displayed image without changing the original data. The filters are applied only to the image viewer. The sub average and sub line filter apply to topography images, whereas the div average filter is used primarily for light intensity measurements.

- **None**
  Displays the raw image, without line correction.

- **Sub Average**
  Before determining the color and the 3D parameters for the displayed image, the average of the current line is subtracted from the original data. To preserve the characteristic value of the data, the total average of the image is added.

- **Div Average**
  Before determining the color and the 3D parameters for the displayed image, the original data points are divided by the average of the current line. To preserve the characteristic value of the data, the total average of the image is multiplied.

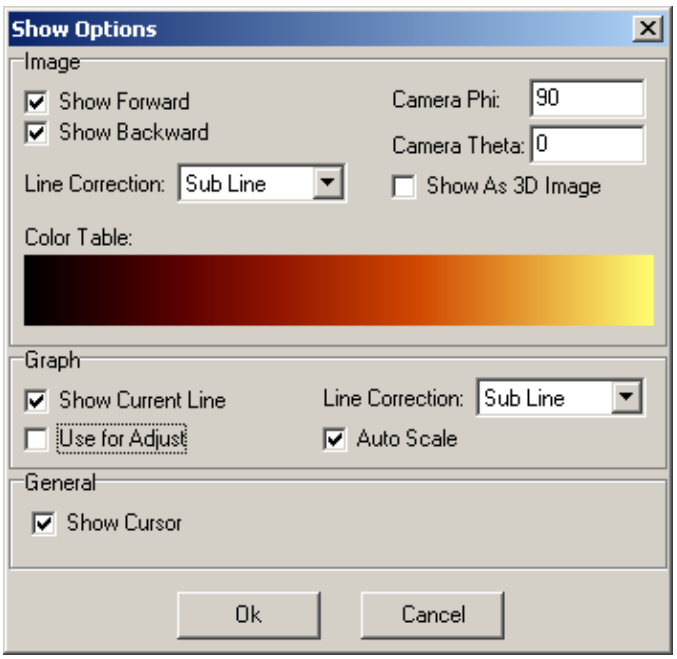

Fig. 3.2: Online data display.

► **Sub Line**
Before determining the color and the 3D parameters for the displayed image, a linear slope, calculated from the current line by linear regression, is subtracted from the original data points. To preserve the characteristic value of the data, the total average of the image is added.

If the Show As 3D Image box is checked, the image will be displayed in a 3D view.
The Color Table displays the color scale for the image representation. Clicking on the color scale with the right mouse button will open a context menu. This provides quick access to various color profiles.

Graph

The signal acquired in a channel can be represented in a graph viewer. Checking the box Use for Adjust will display the acquired signal as a function of time.
Checking the box Show Current Line will display the current scan line as an oscilloscope trace in a graph viewer. Line correction filters can be applied to the data displayed in the graph viewer.

General

When enabled, a cursor for the corresponding unit is created and a cursor viewer is opened together with this channel.

3.3 Spectral Data Acquisition

This section describes the different types of spectral data acquisition. These basic types are used by several different acquisition modes.
All parameters that control the spectral data acquisition are explained in this section. They will appear in various tab sheets of the spectroscopy options window.

3.3.1 Single Spectrum Acquisition

A single spectrum acquisition stores only one spectrum. This spectrum can be an accumulation of several spectra. Two different types of accumulations can be defined. The so-called hardware accumulation can be used together with the cosmic ray removal (CRR) function. In order to preview the current spectrum when configured for long integration times, the user should use software accumulations. This type of accumulation can be used with the average function.
The acquisition mode determines if the sample is moved before the acquisition of the spectrum begins. The calibration for this spectrum is taken from the current settings of the spectrograph (see Section 2.4). The single spectrum acquisition is controlled by the following parameters:

Integration Time
: This parameter defines the integration time for one spectrum. It must be set in s. The minimum and maximum integration times depend on the acquisition mode and the CCD controller hardware settings (see Section 2.3).

Hardware Accumulations
: This parameter sets the number of hardware accumulations. The accumulations are performed by the CCD controller. These accumulations can be used in combination with the cosmic ray removal filter.

Software Accumulations
: This parameter sets the number of software accumulations. The accumulations are performed by the software. After each software accumulation, the intermediate result is displayed.

CRR
: If the cosmic ray removal filter is activated, consecutive scans in an accumulation will be compared and any cosmic ray-like features that are only present in one scan will be replaced with a scaled version of the corresponding pixel value in the correct scan. The number of hardware accumulations must be larger than one.

Average

If this check box is activated, the software will average the software accumulations. This keeps the preview in the same scaling range.

3.3.2 Time Spectrum Acquisition

The time spectrum acquisition stores a time series of single spectra. A single spectrum of the series can be an accumulation of several spectra. The time between the accumulations and the time between the spectra can be controlled independently of the spectrum integration time. Fig. 3.3 illustrates how the timing parameters control the time spectrum acquisition.
The acquisition mode determines if the sample is moved before the acquisition of the spectra begins. The calibration for the spectra is taken at the beginning of the measurement from the current settings of the spectrograph (see Section 2.4). The time spectrum acquisition is controlled by the following parameters:

Integration Time

This parameter defines the integration time t_{int} for one spectrum. It must be set in s. The minimum and maximum integration times depend on the acquisition mode and the CCD controller hardware settings (see Section 2.3).

Accumulation Cycle Time

The time between the accumulations t_{acc} can be set with this parameter. It must be greater than or equal to the integration time.

Cycle Time

The time between the accumulated spectra t_{cycle} is controlled by this parameter. The cycle time must yield to the following condition:

$$t_{cycle} \geq (N_{h.acc.} - 1)t_{acc} + t_{int} \tag{3.1}$$

Hardware Accumulations

This parameter sets the number of hardware accumulations $N_{h.acc.}$. The accumulations are performed by the CCD controller. These accumulations can be used in combination with the cosmic ray removal filter.

Number of Spectra

The number of spectra parameter controls how many spectra are taken in one series. The minimum value is 4 spectra, the maximum value is 8192.

CRR

If the cosmic ray removal filter is activated, consecutive scans in an accumulation will be compared and any cosmic ray-like features that are only present

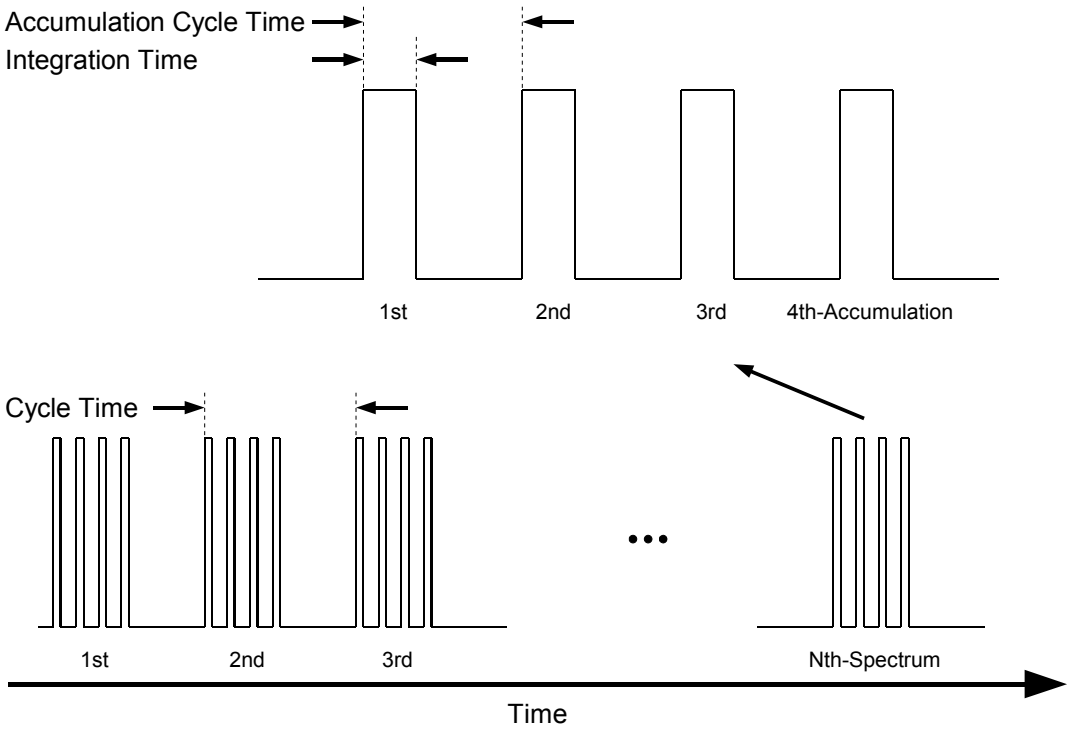

Fig. 3.3: Timing for time spectrum acquisition.

in one scan will be replaced with a scaled version of the corresponding pixel value in the correct scan. The number of hardware accumulations must be larger than one.

3.3.3 Image Spectrum Acquisition

The image spectrum acquisition stores a two-dimensional array of spectra in order to extract images from the sample. The time between the spectra is controlled by an external pixel trigger which is generated by the signal image scan or the depth scan procedure (see Section 3.1.4 and Section 3.1.5). The time between these pixel triggers defines the effective integration time for the spectra. This effective integration time is larger than the integration time, because it also contains the read out time for the spectra.
The calibration for the spectra is taken at the beginning of the measurement from the current settings of the spectrograph (see Section 2.4). The image spectrum acquisition is controlled by the following parameters:

Integration Time

This parameter defines the integration time for one spectrum. It must be set in s. The minimum and maximum integration times depend on the acquisition mode and the CCD controller hardware settings (see Section 2.3).

Points per Line

This parameter is part of the signal image scan or the depth scan procedure. It defines the number of spectra in one line.

Lines Per Image

This parameter is part of the signal image scan or the depth scan procedure. It defines the size of the two-dimensional array.

HINT This acquisition mode requires sufficient computer memory. A spectrum with 1024 pixels is stored into 2048 bytes. If the Image spectrum acquires a 512×512 pixel array, the memory requirement will be 512 MB.

3.3.4 Full Chip Acquisition

The full chip mode is only needed for the adjustment of the CCD. The two-dimensional array of the CCD is displayed as an image in order to focus and place the spectrum horizontally onto the chip. The full chip acquisition is controlled by the following parameters:

Integration Time

This parameter defines the integration time for one image. It must be set in s. The minimum and maximum integration times depend on the acquisition mode and the CCD controller hardware settings (see Section 2.3).

Horizontal Binning

This parameter determines how many pixels should be combined horizontally into one pixel.

Vertical Binning

This parameter determines how many pixels should be combined vertically into one pixel. Increasing this parameter will reduce the read out time.

Chapter 4

Acquisition Modes

This chapter describes the various modes of acquisition that the ScanCtrl Spectroscopy Plus software provides. These acquisition modes are usually grouped in categories (methods) such as AFM, SNOM, Raman, etc, and some are available in all methods. This group definition is modifiable by WITec and is subject to change. Unlike the group names, the names of the acquisition modes will not change.

4.1 General Remarks

4.1.1 Bad Parameter Conditions

If an acquisition mode is controlled by more than one parameter, the settings of these may possibly exclude each other. The reason for this might be a restriction of the hardware, e.g. sample rate too high, or a logical problem. If a bad parameter condition exists, the software will mark the corresponding parameters in red. The acquisition mode can not be started until this conflict is resolved.

4.1.2 Availability

This software is designed for many different scanning probe techniques. The availability of the acquisition modes depends on the hardware of the microscope. Only executable acquisition modes are visible.

4.1.3 Naming of the Data Objects

The ScanCtrl Spectroscopy Plus software can store several measurements in one project. In order to distinguish between these measurements, they are assigned individual names. All data objects corresponding to the same measurement will

use this name as a base. This data name is user-definable by two parameters on the tab sheet of the corresponding acquisition mode.

Data Name

This string is used for the name of the data objects, which will be created by the next measurement.

Data Number

This number is added to the Data Name. It will be automatically increased for the next measurement.

4.1.4 Parameter Documentation

Each acquisition mode requires several parameters to move the sample and acquire data. All of these parameters are stored in the text data object, which is added to the current project. Additionally, the date and the time of the beginning of the measurement are stored in the text data object.

4.2 General Functions

4.2.1 Stop 

The stop button can be used to stop a measurement before it is finished. In this case, the measurement does not stop immediately. It will first finish the next sub-function of the current measurement, e.g. finish the actual scan line before the system will be ready for the next scan.

4.2.2 Abort 

Like the stop button, the abort button can be used to interrupt a measurement. It will stop the measurement immediately. This function is used in order to finish a measurement with extremely high integration times. In this case, the scan stage position jumps immediately to its initial position. In order to protect cantilevers, this option is not available in all AFM and SNOM acquisition modes.

4.2.3 Focus Spectrum 

Focus spectrum continuously acquires spectra until the stop button or the abort button is pressed. The spectral acquisition follows the description provided in Section 3.3.1. The spectra are not stored, they are only displayed in a graph viewer. The

sample remains at its current position. Fig. 4.1 shows the tab sheet that controls this mode.

4.2.4 Focus Image 

Focus image continuously acquires an image of the CCD until the stop button or the abort button is pressed. This acquisition follows the description provided in Section 3.3.4. The images are not stored, they are only displayed in an image viewer. The sample remains at its current position. Fig. 4.2 shows the tab sheet that controls this mode.

4.2.5 Move To 

The move to positioning mode will move the sample from the current position to the selected position. The movement will follow the procedure provided in Section 3.1.2. Fig. 4.3 shows the tab sheet that controls this mode.

4.2.6 Move To 2D 

The move to 2D positioning mode will move the sample from the current position to the selected position. The movement will follow the procedure provided in Section 3.1.2. This positioning mode only moves the scanner in the x- and -y-directions. The z-position will remain constant. Fig. 4.4 shows the tab sheet that controls this mode.

4.2.7 Adjust 

The adjust mode is used to optimize a signal before the actual measurement starts. Every analog signal connected to the 8 input channels of the data acquisition board (see Section 2.1) can be displayed in a graph viewer. Unlike all other acquisition modes, this acquisition mode has no tab sheet in the spectroscopy options window. It uses the parameters of the acquisition whose tab sheet is visible in the spectroscopy options window. The channel description of the channels window (see Section 3.2.1), as well as the timing parameters, are used by the adjust procedure. This keeps the signal adjustment comparable to the actual measurement. In order to see the signal of an analog channel, the use for adjust checkbox must be activated in the show options window (Section 3.2.2). The adjust procedure runs until the stop or abort button is pressed.

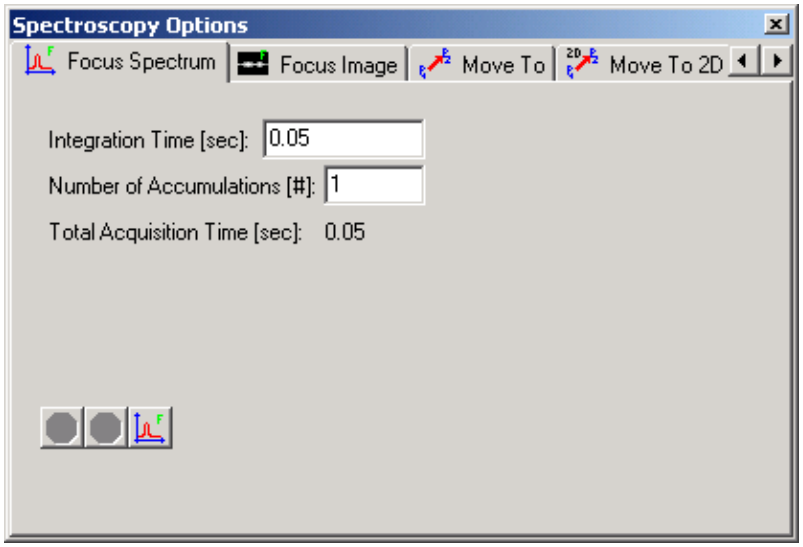

Fig. 4.1: Focus spectrum tab sheet with typical parameters.

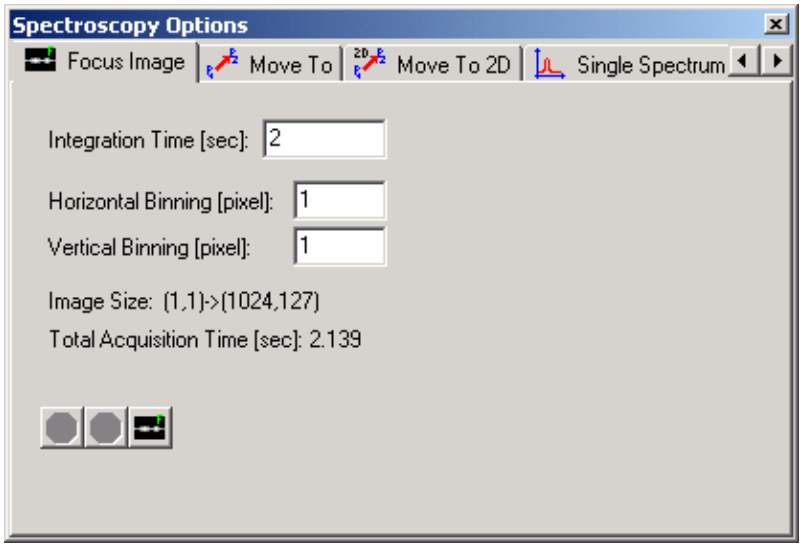

Fig. 4.2: Focus image tab sheet with typical parameters.

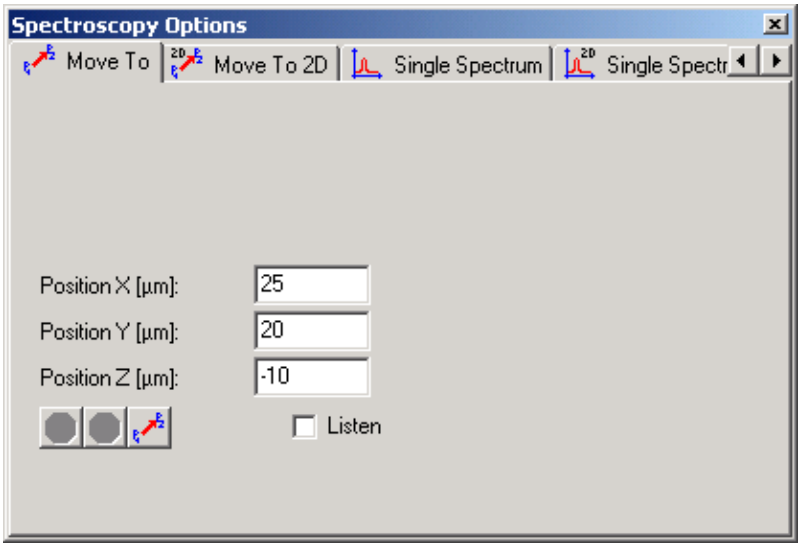

Fig. 4.3: Move to tab sheet with typical parameters.

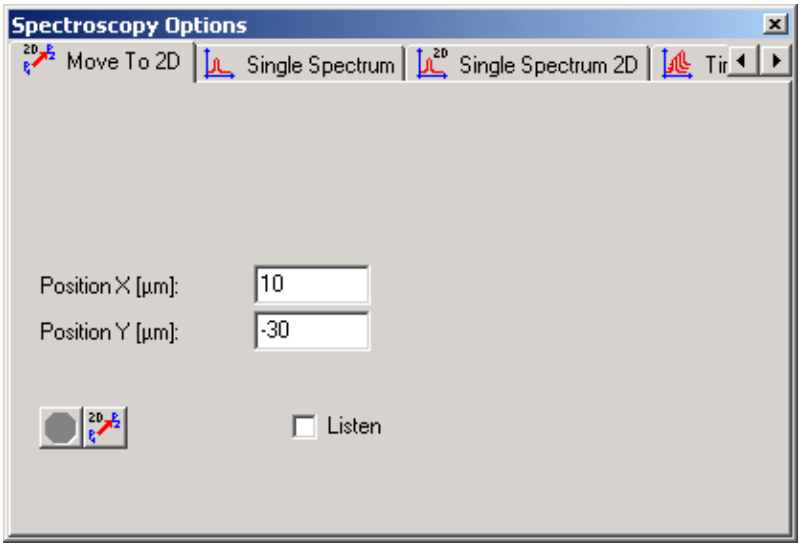

Fig. 4.4: Move to 2D tab sheet with typical parameters.

4.3 Spectroscopy 3D

The following section describes the spectroscopic acquisition modes that can move the sample in three dimensions. These acquisition modes can be used for Raman or fluorescence microscopy. Usually, the modes are grouped in the Raman method.

4.3.1 Single Spectrum 

The single spectrum acquisition mode moves to the desired sample position as described in Section 3.1.2. After this movement, it acquires a single spectrum as described in Section 3.3.1. The measurement stops automatically after the spectrum has been acquired. Fig. 4.5 shows all user-definable parameters with examples of typical values.
The spectrum is stored in a graph data object and automatically displayed in a graph viewer.

4.3.2 Time Spectrum 

The time spectrum acquisition mode moves to the desired sample position as described in Section 3.1.2. After this movement, it acquires a series of spectra as described in Section 3.3.2. The measurement stops automatically after all the spectra have been acquired. Fig. 4.6 shows all user-definable parameters with examples of typical values.
The spectra are stored in a graph data object and are automatically displayed in a graph viewer. A filter manager is created as well, in order to facilitate analysis of the spectra. The current spectrum is displayed while the measurement runs.

4.3.3 Line Spectrum 

The line spectrum acquisition mode acquires spectra along a user-definable line. The movement of the sample is described in Section 3.1.3. Each spectra acquisition follows the procedure described in Section 3.3.1. The measurement stops automatically after all the spectra have been acquired. Fig. 4.7 shows all user-definable parameters with examples of typical values.
All spectra are stored in one graph data object and automatically displayed in a graph viewer. A filter manager is created as well, in order to facilitate analysis of the spectra. The current spectrum is displayed while the measurement runs.

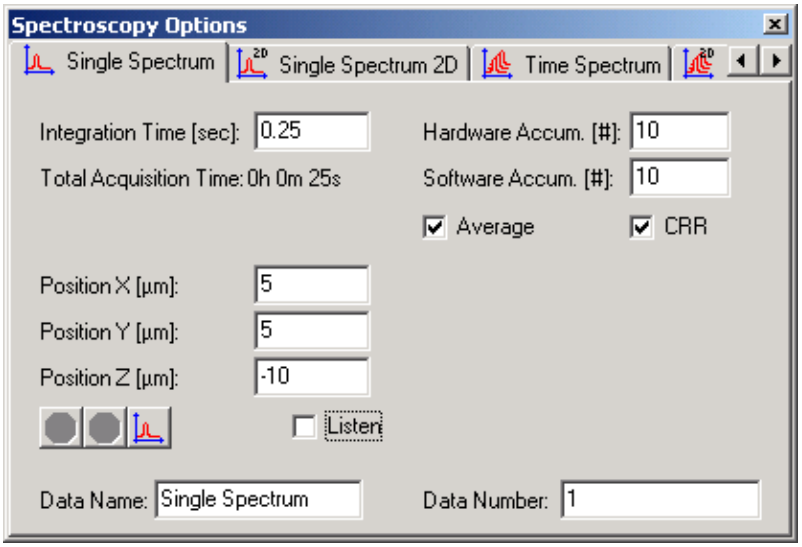

Fig. 4.5: Single spectrum tab sheet with typical parameters.

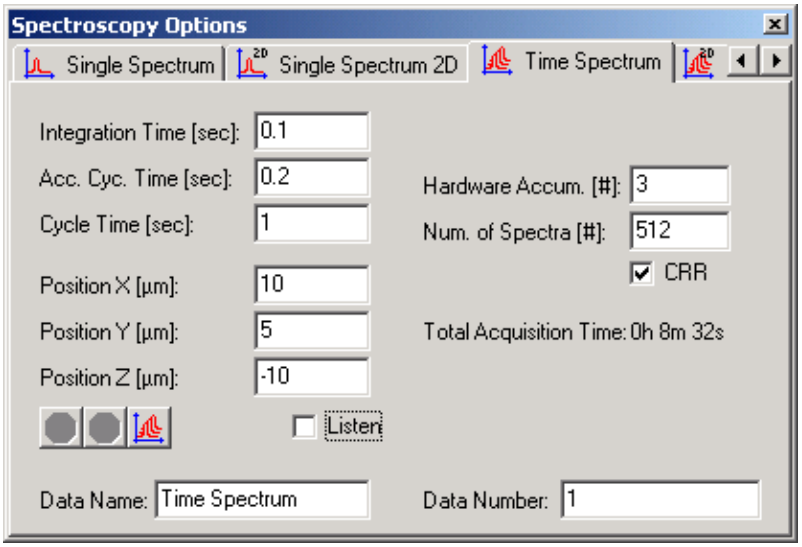

Fig. 4.6: Time spectrum tab sheet with typical parameters.

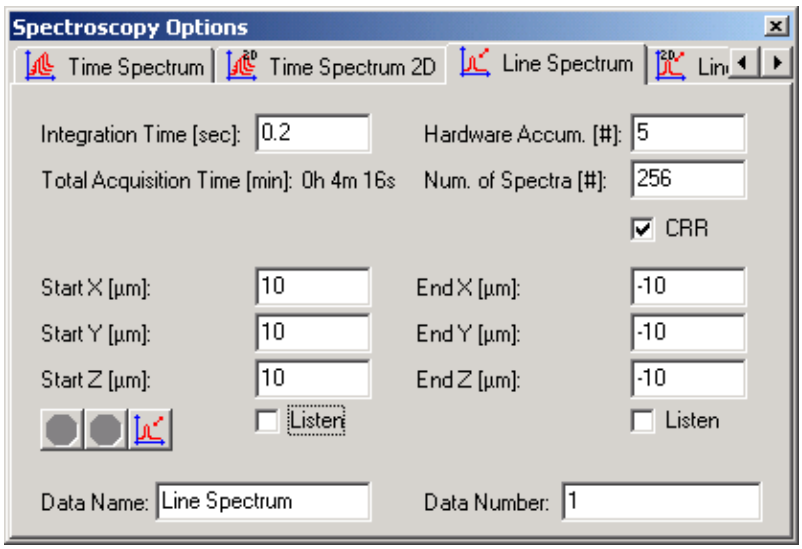

Fig. 4.7: Line spectrum tab sheet with typical parameters.

4.3.4 Image Spectrum 

The image spectrum acquisition mode scans a rectangular area. The user can choose from two different scan modes. The single image scan is described in Section 3.1.4 and the depth scan in Section 3.1.5. A spectrum and up to 8 analog signals are acquired at each pixel of the image. The spectral acquisition follows the procedure as described in Section 3.3.3. The analog signal acquisition and interpretation is explained in Section 3.2. The measurement stops automatically after all the spectra have been acquired. Fig. 4.8 shows all user-definable parameters with examples of typical values.
All spectra are stored in one graph data object and automatically displayed in a graph viewer. A filter manager is created as well, in order to facilitate analysis of the spectra. The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel. The current spectrum is displayed while the measurement runs.

4.3.5 Fast Image 

The fast image acquisition mode can be used to detect only a small spectral region of the spectrum with a highly sensitive detector installed at the second exit slit of the spectrograph. To acquire data in this mode, the mirror inside the spectrograph is flipped to the second exit slit. Only light around the spectral center (see Section 2.4.1) falls onto the exit slit.
After this, the acquisition mode scans a rectangular area or box. The user can choose from among three different scan modes. The single image scan is described

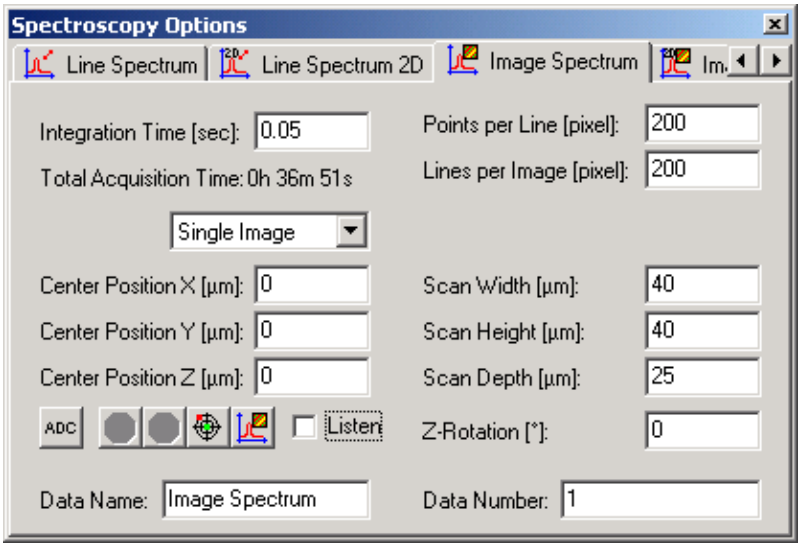

Fig. 4.8: Image spectrum tab sheet with typical parameters.

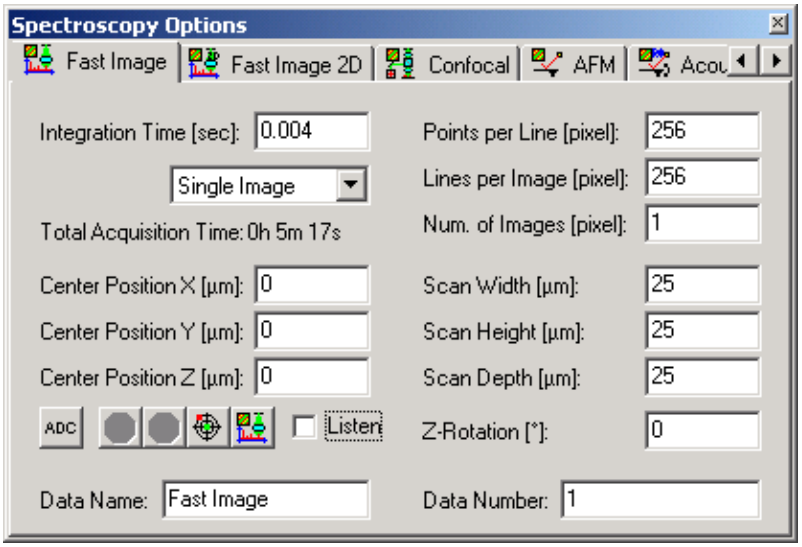

Fig. 4.9: Fast image tab sheet with typical parameters.

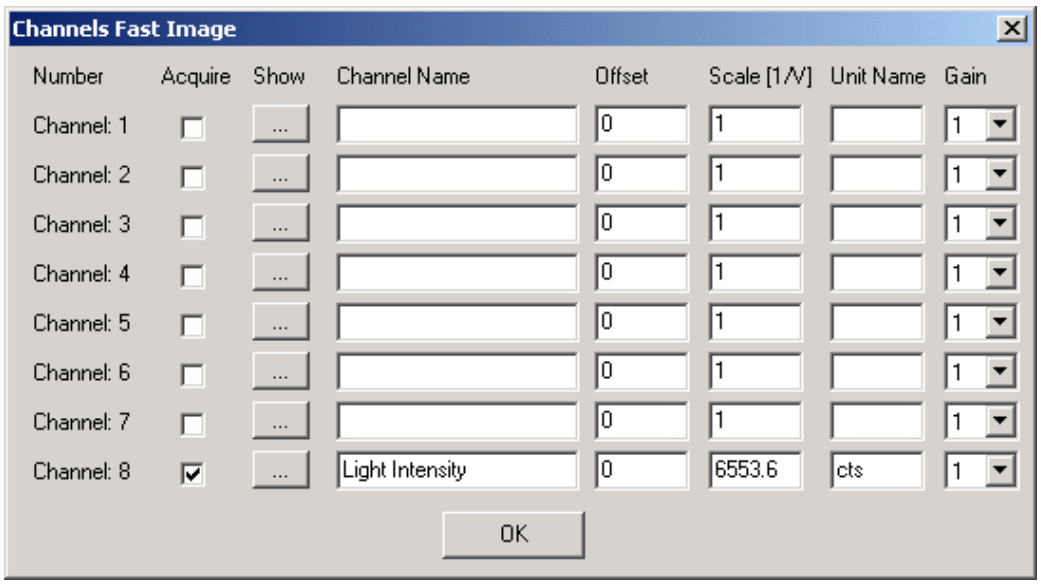

Fig. 4.10: Channels window for fast image with typical parameters.

in Section 3.1.4, the depth scan in Section 3.1.5, and the image stack scan in Section 3.1.6. Up to 8 analog signals are acquired at each pixel of the image or image stack. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 7 or 8 to detect the light intensity which falls onto a single photon counting device. The typical channel selection and its interpretation are shown in Fig. 4.10. The measurement stops automatically after the data has been acquired.
Fig. 4.9 shows all user-definable parameters with examples of typical values. The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.3.6 External Image Spectrum 

The external image spectrum acquisition mode can be used to control external hardware and software for spectral data acquisition. The scan engine of the ScanCtrl Spectroscopy Plus software creates a hardware trigger for each pixel. The so-called pixel trigger is a TTL signal and can be used to synchronize the external hardware with the scan. Spectral data acquired with WinSpec software can be imported into WITec Project or ScanCtrl Spectroscopy Plus. For more details on importing *.spe files, please read the WITec Project manual.
The external image spectrum acquisition mode allows the user to scan a rectangular area or box. The user can choose from among three different scan modes. The single image scan is described in Section 3.1.4, the depth scan in Section 3.1.5, and the image stack in Section 3.1.6. In addition to the external control hardware, the software acquires up to 8 analog signals at each pixel. The analog signal ac-

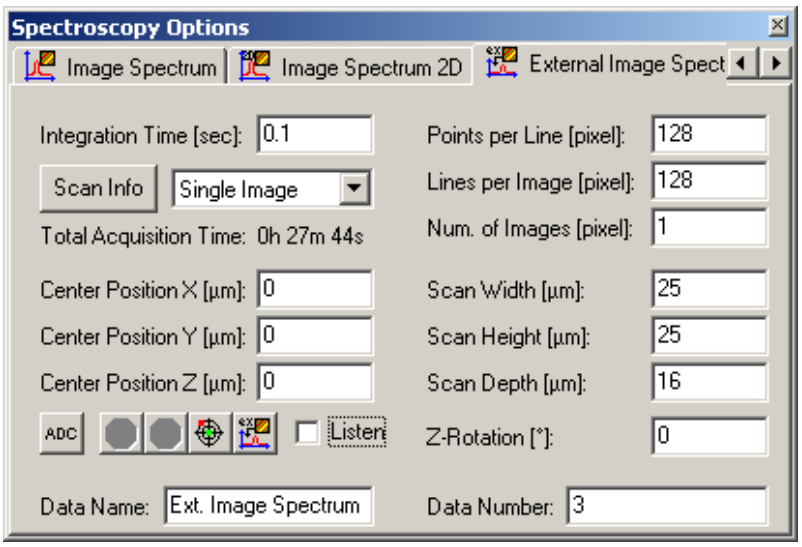

Fig. 4.11: External image spectrum tab sheet with typical parameters.

quisition and interpretation is explained in Section 3.2. The measurement stops automatically. Fig. 4.11 shows all user-definable parameters with examples of typical values.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.
Some additional information about the scan will be provided when the user presses the Scan Info button. This information can help to initialize the external software.

4.4 Confocal Microscopy

The following section describes the confocal acquisition modes that can move the sample in three dimensions. These acquisition modes can be used for fluorescence, reflection, or transmission confocal microscopy. Usually, these modes are grouped in the confocal method.

4.4.1 Confocal 

The confocal acquisition mode can be used to detect fluorescence or reflected light with a highly sensitive detector. This acquisition mode scans a rectangular area or box. The user can choose from among three different scan modes. The single image scan is described in Section 3.1.4, the depth scan in Section 3.1.5, and the image stack scan in Section 3.1.6. Up to 8 analog signals are acquired at each pixel of the image or image stack. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 7 or 8 to detect the light intensity

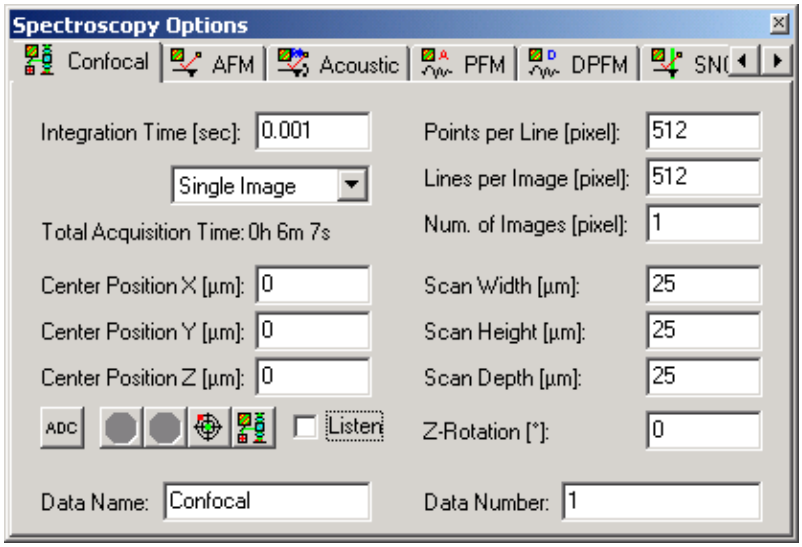

Fig. 4.12: Confocal tab sheet with typical parameters.

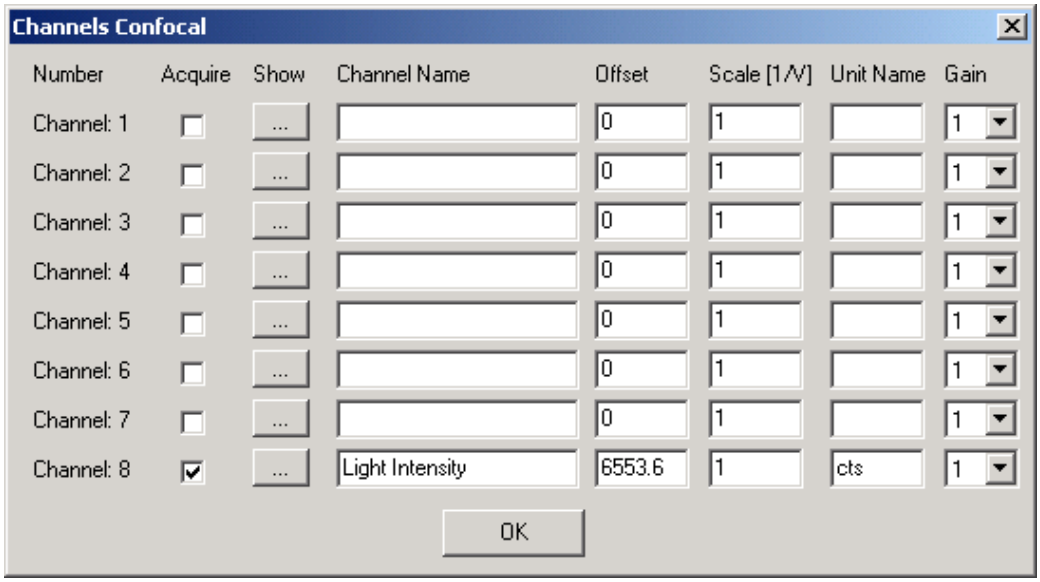

Fig. 4.13: Channels window for confocal with typical parameters.

which falls onto a single photon counting device. The typical channel selection and its interpretation are shown in Fig. 4.13. The measurement stops automatically after the data has been acquired.
Fig. 4.12 shows all user-definable parameters with examples of typical values. The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.5 Atomic Force Microscopy

This section describes the features of the ScanCtrl Spectroscopy Plus software for Atomic Force Microscopy. Usually, all Atomic Force Microscopy modes are grouped in the AFM method.

4.5.1 AFM 

The AFM acquisition mode should be used for AFM contact measurements. It scans a rectangular area. The single image scan is described in Section 3.1.4. User-definable parameters with examples of typical values are shown in Fig. 4.14.
Up to 8 analog signals are acquired at each pixel of the image. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 1 for the topography signal, channel 2 for the deflection signal, and channel 5 for the friction signal. This typical channel selection and its interpretation are shown in Fig. 4.15. A list of their typical show options parameters is given in Tab. 4.1.

Image Parameters	**Topography**	**Deflection**	**Friction**
Show Forward	☒	☐	☐
Show Backward	☒	☐	☐
Line Correction	Sub Line	None	None
Graph Parameters	**Topography**	**Deflection**	**Friction**
Show Current Line	☒	☐	☐
Line Correction	Sub Line	None	None
Use for Adjust	☐	☒	☒
Auto Scale	☐	☐	☐

Table 4.1: Show options parameters for AFM contact mode.

The measurement stops automatically after the image has been acquired.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

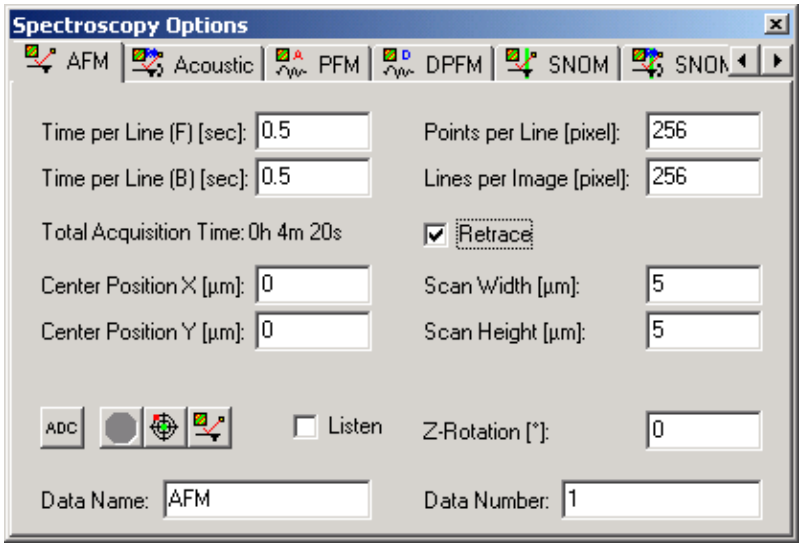

Fig. 4.14: AFM contact mode tab sheet with typical parameters.

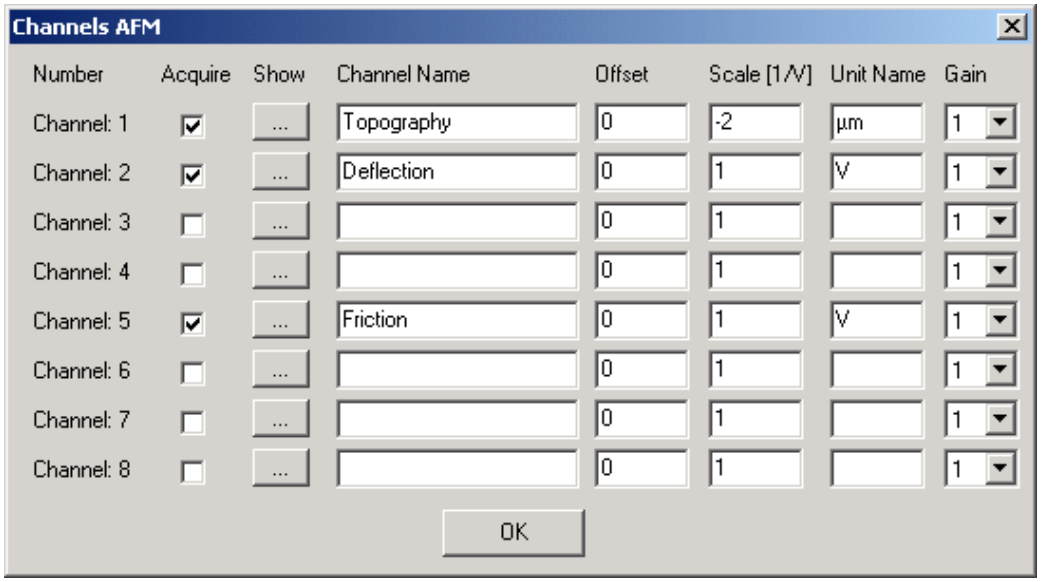

Fig. 4.15: Channels window for AFM contact mode with typical parameters.

4.5.2 Acoustic 

The acoustic acquisition mode should be used for AFM measurements with resonant cantilever excitation. It scans a rectangular area. The single image scan is described in Section 3.1.4. User-definable parameters with examples of typical values are shown in Fig. 4.14.
Up to 8 analog signals are acquired at each pixel of the image. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 1 for the topography signal and channel 3 for the phase shift signal. This typical channel selection and its interpretation are shown in Fig. 4.17. A list of their typical show options parameters is given in Tab. 4.2.

Image Parameters	**Topography**	**Phase**
Show Forward	☒	☒
Show Backward	☐	☐
Line Correction	Sub Line	None
Graph Parameters	**Topography**	**Phase**
Show Current Line	☒	☐
Line Correction	Sub Line	None
Use for Adjust	☐	☐
Auto Scale	☐	☐

Table 4.2: Show options parameters for AFM acousitc mode.

The measurement stops automatically after the image has been acquired.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.5.3 PFM 

The PFM acquisition mode should be used for analog pulsed force mode measurements. It scans a rectangular area. The single image scan is described in Section 3.1.4. User-definable parameters with examples of typical values are shown in Fig. 4.18.
Up to 8 analog signals are acquired at each pixel of the image. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 1 for the topography signal, channel 3 for the stiffness signal, and channel 4 for the adhesion signal. This typical channel selection and its interpretation are shown in Fig. 4.19. A list of their typical show options parameters is given in Tab. 4.3.

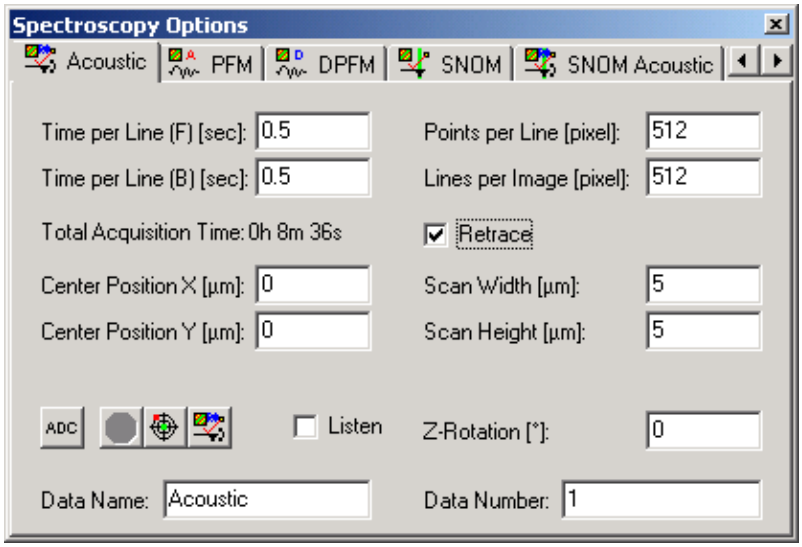

Fig. 4.16: AFM acoustic mode tab sheet with typical parameters.

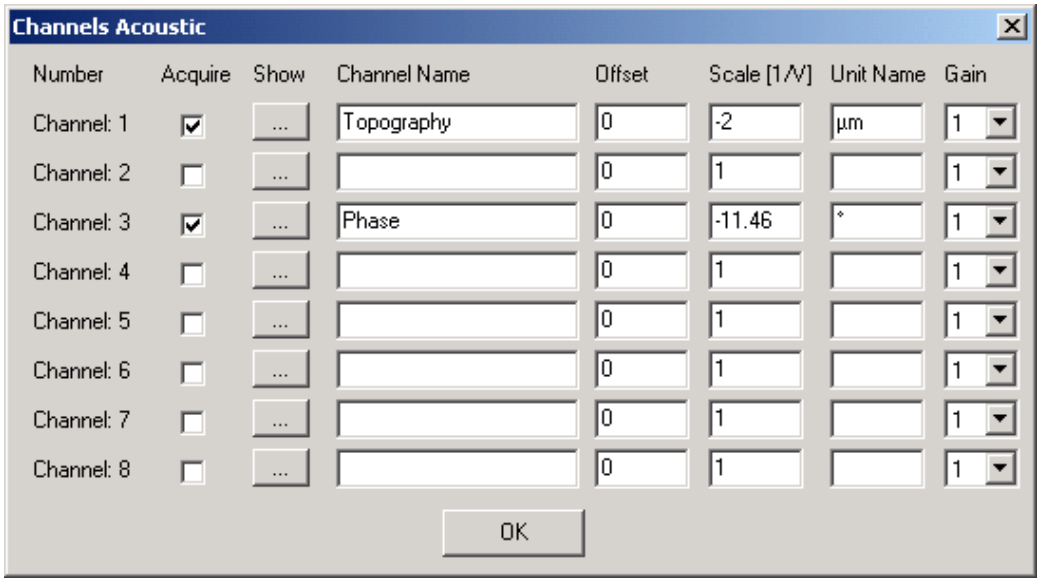

Fig. 4.17: Channels window for AFM acoustic mode with typical parameters.

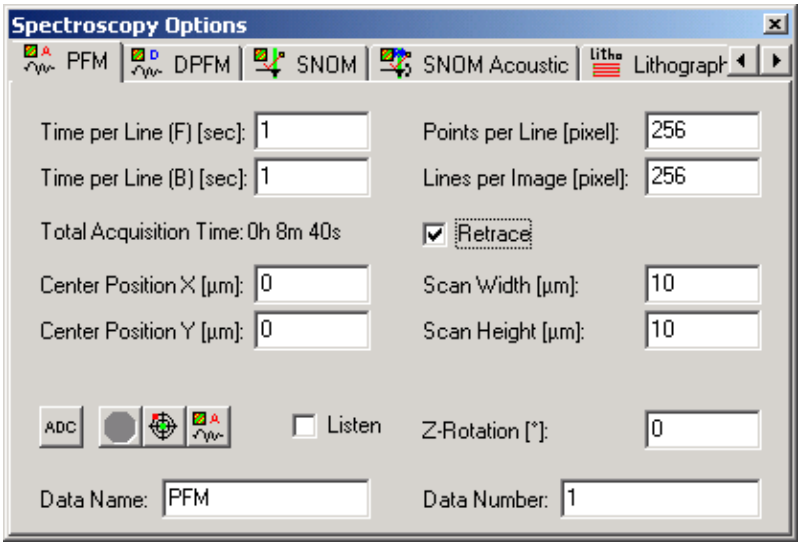

Fig. 4.18: Analog pulsed force mode tab sheet with typical parameters.

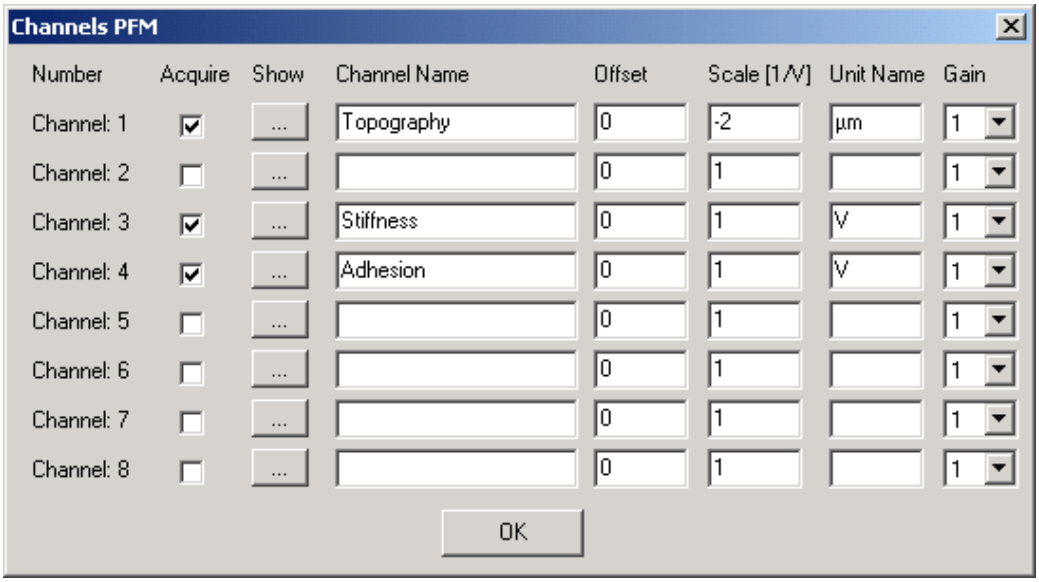

Fig. 4.19: Channels window for analog pulsed force mode with typical parameters.

Image Parameters	Topography	Stiffness	Adhesion
Show Forward	☒	☒	☒
Show Backward	☐	☐	☐
Line Correction	Sub Line	None	None
Graph Parameters	**Topography**	**Stiffness**	**Adhesion**
Show Current Line	☒	☐	☐
Line Correction	Sub Line	None	None
Use for Adjust	☐	☐	☐
Auto Scale	☐	☐	☐

Table 4.3: Show options parameters for PFM contact mode.

The measurement stops automatically after the image has been acquired.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.5.4 DPFM 

The DPFM acquisition mode should be used for digital pulsed force mode measurements. It scans a rectangular area. The single image scan is described in Section 3.1.4. User-definable parameters with examples of typical values are shown in Fig. 4.20.
Up to 8 analog signals are acquired at each pixel of the image. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 1 for the topography signal, channel 3 for the stiffness signal, and channel 4 for the adhesion signal. This typical channel selection and its interpretation are shown in Fig. 4.21. A list of their typical show options parameters is given in Tab. 4.4.

Image Parameters	Topography	Stiffness	Adhesion
Show Forward	☒	☒	☒
Show Backward	☐	☐	☐
Line Correction	Sub Line	None	None
Graph Parameters	**Topography**	**Stiffness**	**Adhesion**
Show Current Line	☒	☐	☐
Line Correction	Sub Line	None	None
Use for Adjust	☐	☐	☐
Auto Scale	☐	☐	☐

Table 4.4: Show options parameters for DPFM contact mode.

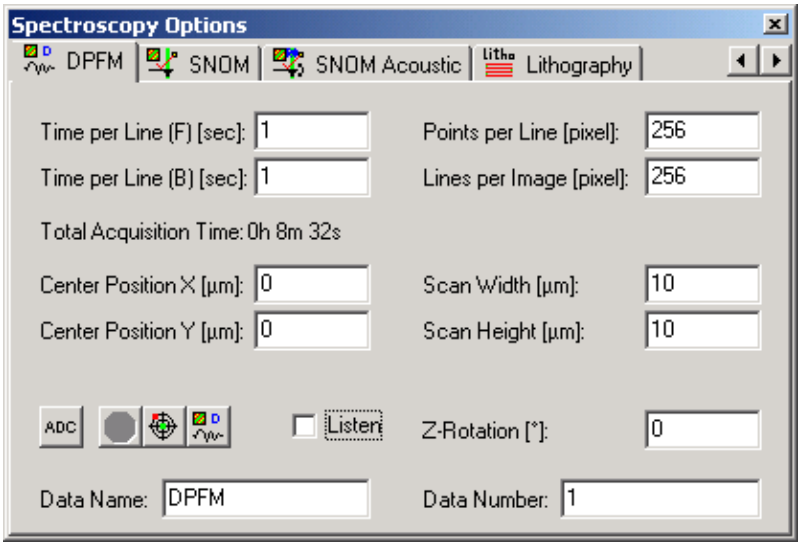

Fig. 4.20: Digital pulsed force mode tab sheet with typical parameters.

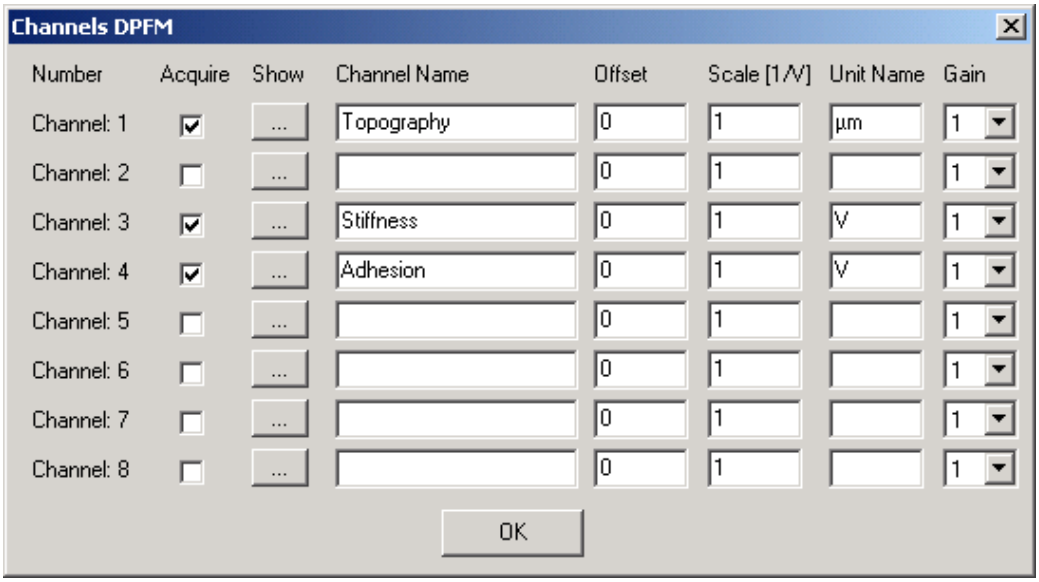

Fig. 4.21: Channels window for digital pulsed force mode with typical parameters.

The measurement stops automatically after the image has been acquired.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.6 Near Field Microscopy

This section describes the features of the ScanCtrl Spectroscopy Plus software for near field microscopy. Usually, all near field microscopy modes which use single photon counting detectors are grouped in the SNOM method.

4.6.1 SNOM 

The SNOM acquisition mode should be used for SNOM contact-mode measurements. It scans a rectangular area. The single image scan is described in Section 3.1.4. User-definable parameters with examples of typical values are shown in Fig. 4.22.
Up to 8 analog signals are acquired at each pixel of the image. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 1 for the topography signal, and channel 7 or 8 for the Light Intensity signal. This typical channel selection and its interpretation are shown in Fig. 4.23. A list of their typical show options parameters is given in Tab. 4.5.

Image Parameters	**Topography**	**Light Intensity**
Show Forward	☒	☐
Show Backward	☐	☐
Line Correction	Sub Line	None
Graph Parameters	**Topography**	**Light Intensity**
Show Current Line	☒	☐
Line Correction	Sub Line	None
Use for Adjust	☐	☒
Auto Scale	☐	☒

Table 4.5: Show options parameters for SNOM contact mode.

The measurement stops automatically after the image has been acquired.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

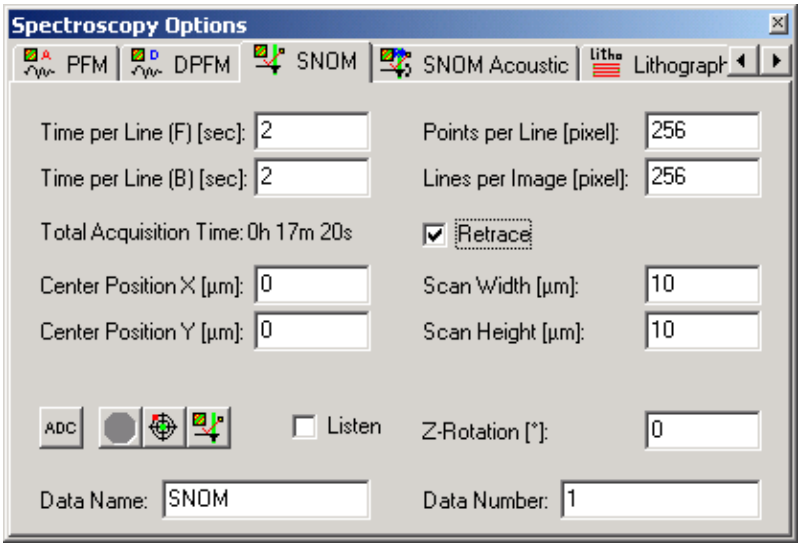

Fig. 4.22: SNOM contact mode tab sheet with typical parameters.

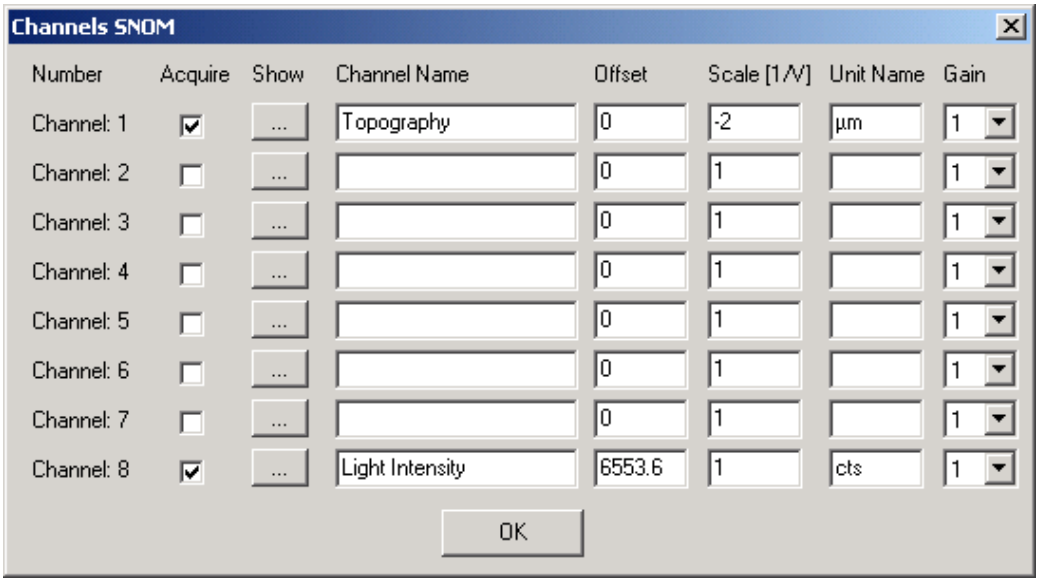

Fig. 4.23: Channels window for SNOM contact mode with typical parameters.

4.6.2 SNOM Acoustic 

The SNOM acoustic acquisition mode should be used for measurements with resonant SNOM-cantilever excitation. It scans a rectangular area. The single image scan is described in Section 3.1.4. User-definable parameters with examples of typical values are shown in Fig. 4.24.
Up to 8 analog signals are acquired at each pixel of the image. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 1 for the topography signal, channel 3 for the phase shift signal, and channel 7 or 8 for the Light Intensity signal. This typical channel selection and its interpretation are shown in Fig. 4.25. A list of their typical show options parameters is given in Tab. 4.6.

Image Parameters	**Topography**	**Phase**	**Light Intensity**
Show Forward	☒	☐	☐
Show Backward	☐	☐	☐
Line Correction	Sub Line	None	None
Graph Parameters	**Topography**	**Phase**	**Light Intensity**
Show Current Line	☒	☐	☐
Line Correction	Sub Line	None	None
Use for Adjust	☐	☐	☒
Auto Scale	☐	☐	☒

Table 4.6: Show options parameters for SNOM acoustic mode.

The measurement stops automatically after the image has been acquired.
The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.7 Spectroscopy 2D

The following section describes the spectroscopic acquisition modes that move the sample in only the x- and y-directions. These modes can be used if an AFM- or SNOM-Tip is in contact with the sample and can be used for Raman, fluorescence, or transmission spectroscopy. Usually, the modes are grouped in the spectroscopy 2D method.

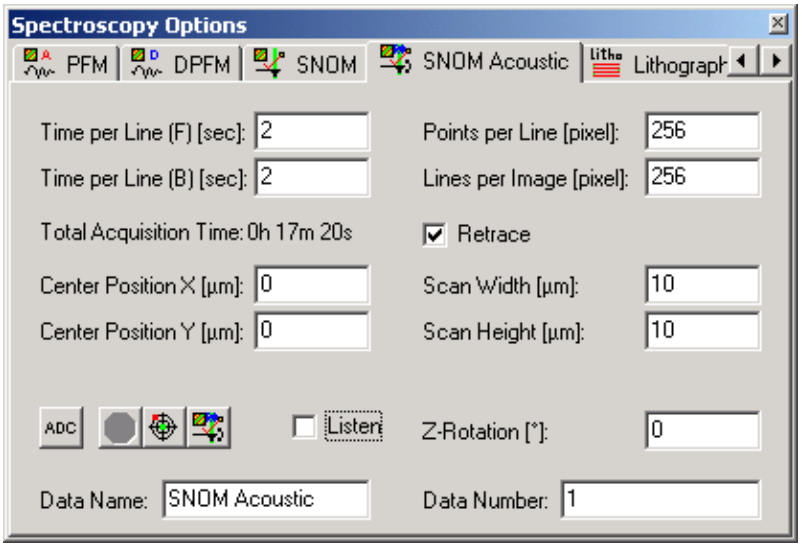

Fig. 4.24: SNOM acoustic mode tab sheet with typical parameters.

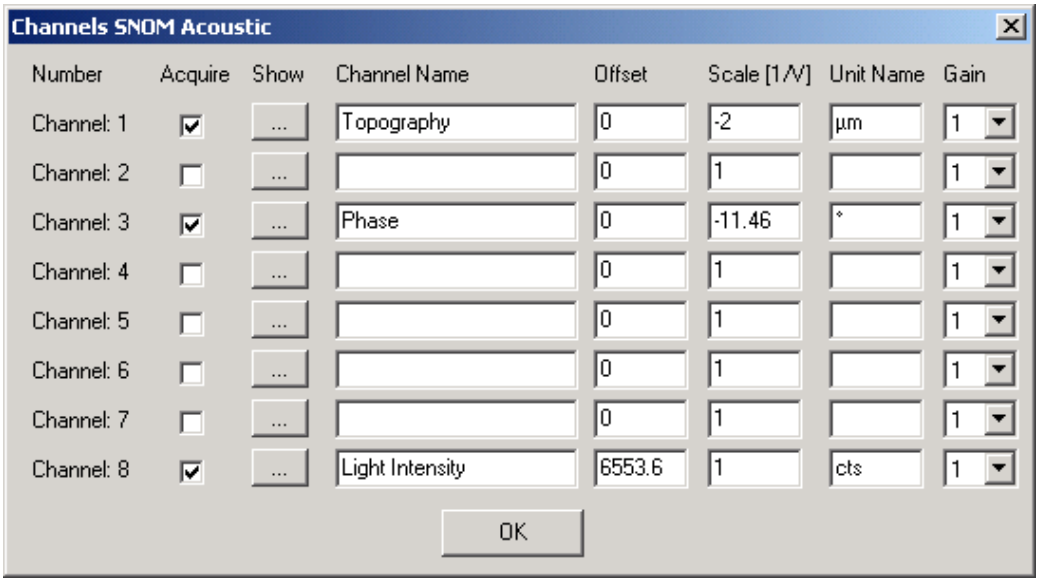

Fig. 4.25: Channels window for SNOM acoustic mode with typical parameters.

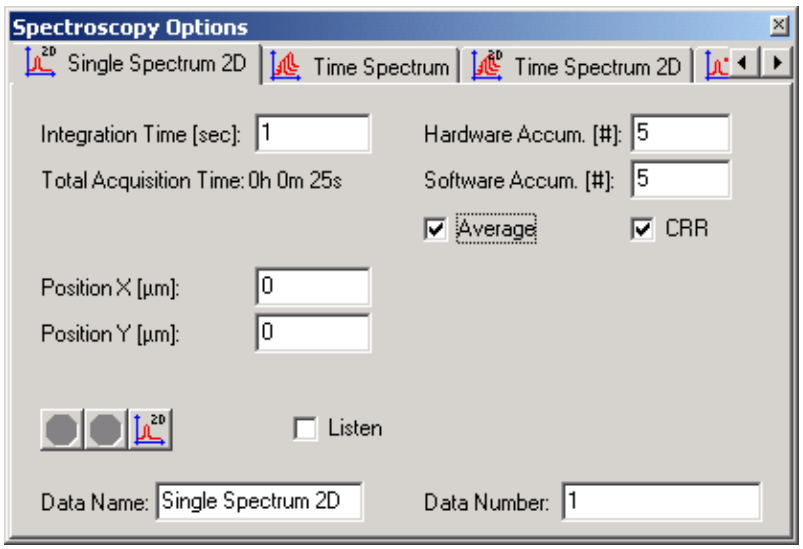

Fig. 4.26: Single spectrum 2D tab sheet with typical parameters.

4.7.1 Single Spectrum 2D 

The single spectrum 2D acquisition mode moves to the desired sample position as described in Section 3.1.2. After this movement, it acquires a single spectrum as described in Section 3.3.1. The measurement stops automatically after the spectrum has been acquired. Fig. 4.26 shows all user-definable parameters with examples of typical values.
The spectrum is stored in a graph data object and automatically displayed in a graph viewer.

4.7.2 Time Spectrum 2D 

The time spectrum 2D acquisition mode moves to the desired sample position as described in Section 3.1.2. After this movement, it acquires a series of spectra as described in Section 3.3.2. The measurement stops automatically after all the spectra have been acquired. Fig. 4.27 shows all user-definable parameters with examples of typical values.
The spectra are stored in a graph data object and automatically displayed in a graph viewer. A filter manager is created as well, in order to facilitate analysis of the spectra. The current spectrum is displayed while the measurement runs.

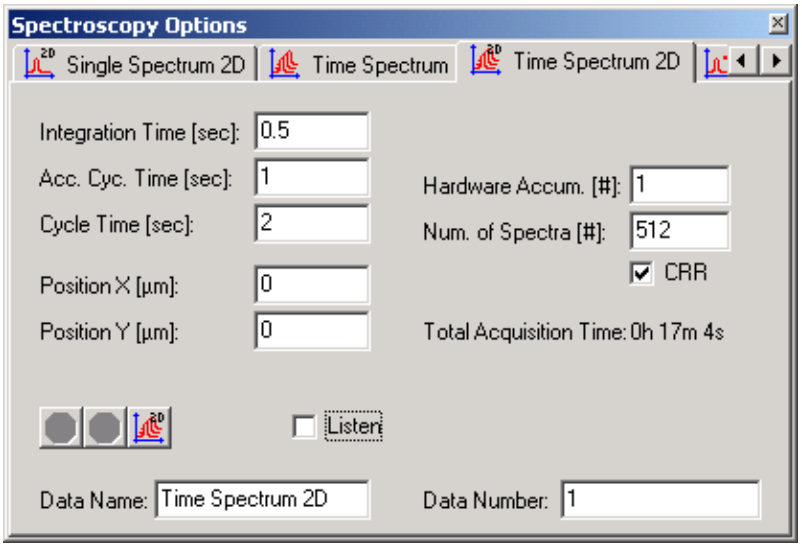

Fig. 4.27: Time spectrum 2D tab sheet with typical parameters.

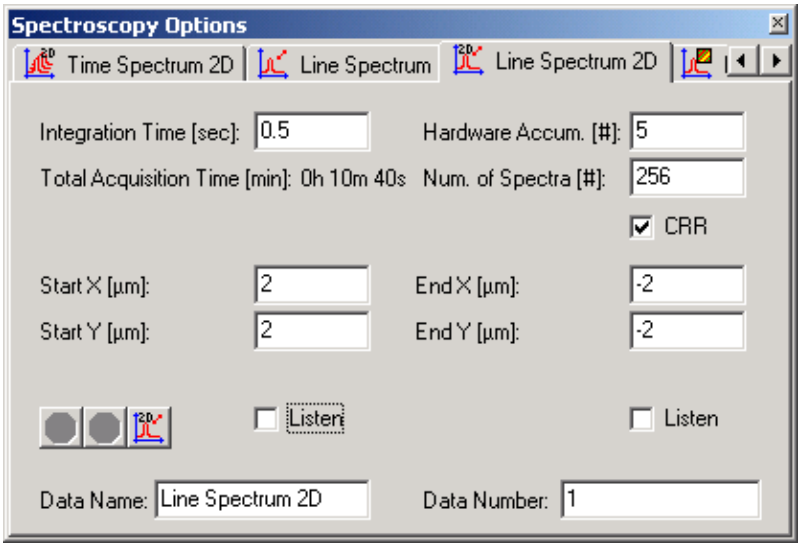

Fig. 4.28: Line spectrum 2D tab sheet with typical parameters.

4.7.3 Line Spectrum 2D 

The line spectrum 2D acquisition mode acquires spectra along a user-definable line. The movement of the sample is described in Section 3.1.3. Each spectra acquisition follows the procedure described in Section 3.3.1. The measurement stops automatically after all the spectra have been acquired. Fig. 4.28 shows all user-definable parameters with examples of typical values.
All spectra are stored in one graph data object and automatically displayed in a graph viewer. A filter manager is created as well, in order to facilitate analysis of the spectra. The current spectrum is displayed while the measurement runs.

4.7.4 Image Spectrum 2D 

The image spectrum 2D acquisition mode scans a rectangular area. The single image scan is described in Section 3.1.4. A spectrum and up to 8 analog signals are acquired at each pixel of the image. The spectral acquisition follows the procedure as described in Section 3.3.3. The analog signal acquisition and interpretation is explained in Section 3.2. The measurement stops automatically after all the spectra have been acquired. Fig. 4.29 shows all user-definable parameters with examples of typical values.
All spectra are stored in one graph data object and automatically displayed in a graph viewer. A filter manager is created as well, in order to facilitate analysis of the spectra. The analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel. The current spectrum is displayed while the measurement runs.

4.7.5 Fast Image 2D 

The fast image 2D acquisition mode can be used to detect only a small spectral region of the spectrum with a highly sensitive detector installed at the second exit slit of the spectrograph. To acquire data in this mode, the mirror inside the spectrograph is flipped to the second exit slit. Only light around the spectral center (see Section 2.4.1) falls onto the exit slit.
After this, the acquisition mode scans a rectangular area. The single image scan is described in Section 3.1.4. Up to 8 analog signals are acquired at each pixel of the image or image stack. The analog signal acquisition and interpretation is explained in Section 3.2. Usually, WITec Microscopes use channel 7 or 8 to detect the light intensity which falls onto a single photon counting device. This typical channel selection and its interpretation are shown in Fig. 4.31. The measurement stops automatically after the data has been acquired.
Fig. 4.30 shows all user-definable parameters with examples of typical values. The

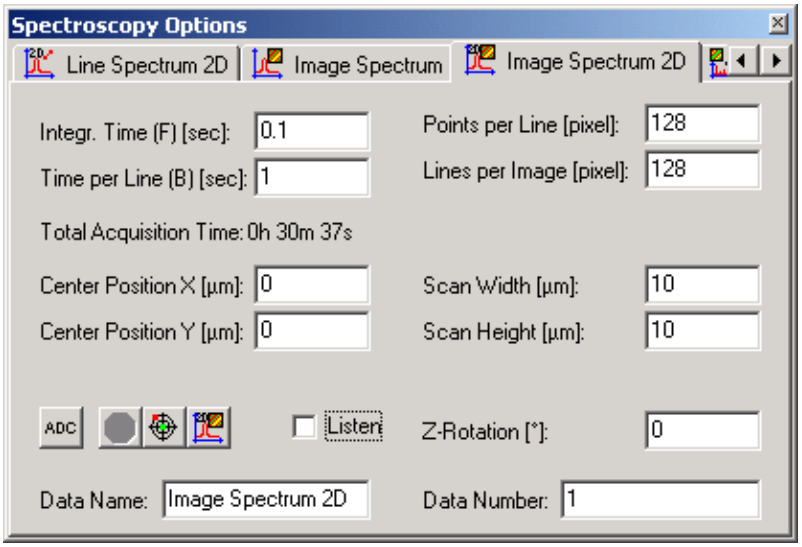

Fig. 4.29: Image spectrum 2d tab sheet with typical parameters.

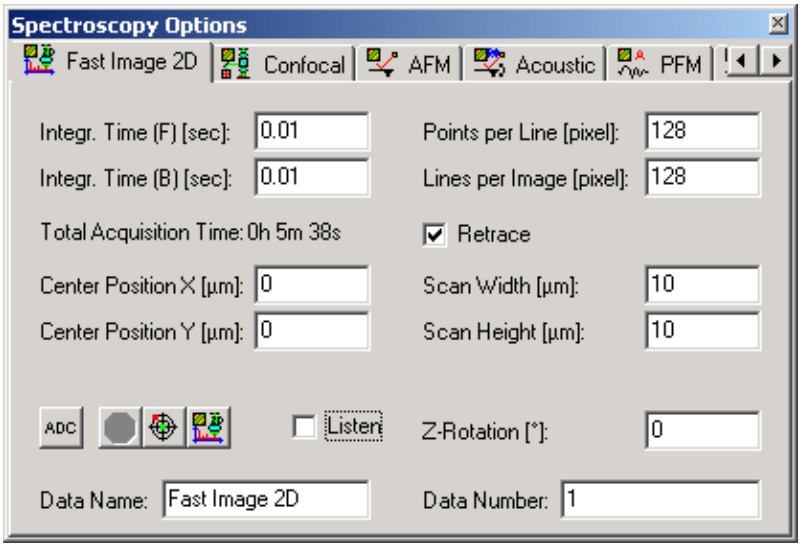

Fig. 4.30: Fast image 2D tab sheet with typical parameters.

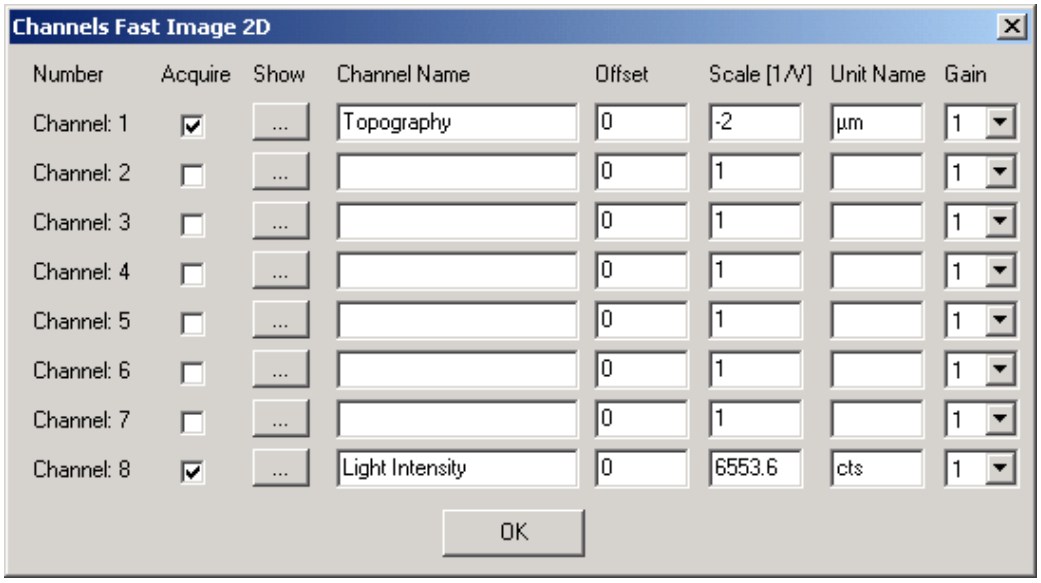

Fig. 4.31: Channels window for fast image 2D with typical parameters.

analog signals are stored in image data objects. The image may be displayed during the measurement (see Section 3.2.2), depending on the attributes of each channel.

4.8 Script Control

The following section describes the lithography mode of the software. The movement of the scan table or the microscope stage can be controlled by an ASCII script. This script can be written in any ASCII editor (e.g. Notepad). The command structure is explained in Section 4.8.2.

4.8.1 Lithography 

The lithography mode is controlled via script (*.txt file). A script file can be selected in a standard file dialog by pressing the ... button. Usually, the speed and scaling is controlled by the script. An overall change of the scan speed and the scaling of the scan table can be done by changing the parameters Speed Scaler and Position Scaler. These scalers only affect the scan table. The speed and scaling of the microscope stage remains unaffected. The origin of the coordinate system is the current position of the scan table and the microscope stage.
After pressing the  button the software checks the script for syntactical errors and impossible movements not supported by the hardware. If this check fails the lithography mode will stop. Otherwise, the script will start operating. The script can be stopped by pressing the button.

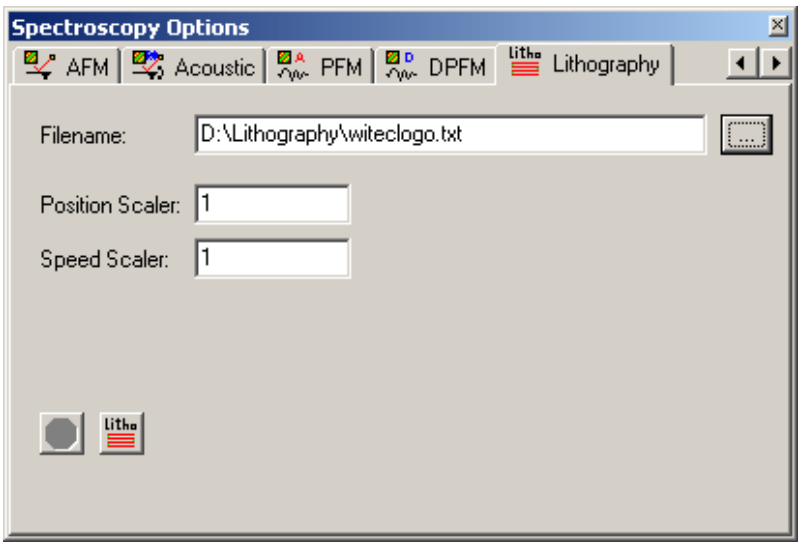

Fig. 4.32: Lithography tab sheet with typical parameters.

4.8.2 Lithography Commands

The script for lithography is an ASCII text file. Every line of the text file can only contain one command followed by its parameters. Comments can be added to the script by using the double slash "//". All characters after the double slash are ignored. A blank line is interpreted as a comment line and has no effect on the microscope movement. Command and parameters must be separated by a space or tabulator. All state parameters remain unchanged unless the responsible command sets the state of the parameter to another value. The origin for movement in the absolute coordinate system is defined by the current position of the scan table and microscope stage before the script has started.
All commands are explained in the following description:

Move Relative

Syntax: `MR X,Y`

The move relative command `MR` moves the scan table relative to the current position. The parameters `X` and `Y` must be set in μm. The movement is a straight line between the current position and the final position. The speed is defined by the scan speed parameter.

Move Absolute

Syntax: `MA X,Y`

The move absolute command `MA` moves the scan table from the current posi-

tion to the absolute position defined by `X` and `Y`. The parameters `X` and `Y` must be set in μm. The movement is a straight line between the current position and the final position. The speed is defined by the scan speed parameter.

Jump Relative

Syntax: `JR X,Y`

The jump relative command `JR` sets the position of the scan table relative to the current position. The parameters `X` and `Y` must be set in μm. The speed depends on the hardware of the scan table.

Jump Absolute

Syntax: `JA X,Y`

The jump absolute command `JA` sets the position of the scan table relative to the origin. The parameters `X` and `Y` must be set in μm. The speed depends on the hardware of the scan table.

Move Upper Microscope Relative

Syntax: `MUMR Z`

The move upper microscope relative command `MUMR` moves the microscope stage relative to its current position. The parameter `Z` must be set in μm.

Move Upper Microscope Absolute

Syntax: `MUMA Z`

The move upper microscope absolute command `MUMA` moves the microscope stage from the current position to the absolute position defined by the parameter `Z`. The parameter `Z` must be set in μm.

Scan Speed

Syntax: `SS Speed`

The scan speed command `SS` sets the scan speed for scan table movement. The `Speed` must be set in $\frac{\mu m}{s}$. The default scan speed is $100\frac{\mu m}{s}$.

Image Trigger

Syntax: `IT State`

The image trigger command `IT` sets the status of the TTL image trigger. This TTL signal can be used to control external devices, e.g. a laser shutter. The `State` can have the status "on" or "off". The initial state of the image trigger is "off".

Status Label

Syntax: `SL Text`

The status label command `SL` sets the `Text` as user information into the status bar of the main window. This command has no effect on the movement of the microscope.

An example script can be found in Appendix A.

There is no warning if the script moves the scan table out of range. If a command moves the scan table out of range, the table will stay at the border until the script moves the table back into the scan range.

Appendix A

Lithography Script Example

The following example moves the scan table in order to draw the WITec logo. At the beginning of the script the upper microscope stage moves $10\,\mu m$ up and the image trigger is turned off. After this, the scan table moves to the start position of the first letter. Before drawing the first letter, the microscope stage moves down and the image trigger is turned on. This procedure is repeated for every letter. At the end of the script the scan table is moved back to starting point.

```
//----------------------
//----- WITec Logo -----
//----------------------
SL WITec Logo:  W
IT off
MUMR 10

//-------- Delay -------
SS 0.1
MR 0.1,0
MR -0.1,0
SS 5

//---------- w ---------
JA 0.1,0.0
MUMR -10
IT on
MA 5.5,0.0
MA 5.9,-7.6
MA 8.7,0.0
MA 9.7,0.0
MA 10.2,-5.8
MA 12.9,0.0
MA 14.0,0.0
MA 10.5,-7.7
MA 9.4,-7.7
MA 8.9,-2.0
MA 5.2,-12.3
MA 4.6,-0.9
MA 0.0,-0.8
MA 0.1,0.0
IT off
MUMR 10

//--------- I ----------
SL WITec Logo:  I
JA 15.3,0.0
MUMR -10
IT on
MA 16.3,0.0
MA 14.9,-7.7
MA 13.9,-7.7
MA 15.3,0.0
IT off
MUMR 10

//--------- T ----------
SL WITec Logo:  T
JA 17.4,0.0
MUMR -10
IT on
MA 22.6,0.0
MA 22.4,-0.8
MA 20.3,-0.8
MA 19.1,-7.7
MA 18.1,-7.7
MA 19.3,-0.8
MA 17.2,-0.8
MA 17.4,0.0
IT off
MUMR 10

//--------- e1 ---------
SL WITec Logo:  E
JA 23.6,-2.1
MUMR -10
IT on
MA 24.7,-2.1
```

```
MA 25.3,-2.3
MA 25.5,-2.5
MA 25.8,-2.8
MA 25.8,-3.7
MA 25.7,-4.0
MA 25.4,-4.3
MA 24.8,-4.7
MA 24.0,-5.0
MA 22.8,-5.2
MA 22.3,-5.2
MA 22.2,-5.8
MA 22.3,-6.4
MA 22.4,-6.6
MA 22.6,-6.8
MA 23.0,-6.9
MA 23.4,-7.0
MA 24.0,-6.9
MA 24.5,-6.8
MA 24.9,-6.6
MA 24.9,-7.3
MA 24.5,-7.5
MA 23.8,-7.6
MA 23.2,-7.7
MA 22.4,-7.6
MA 22.0,-7.5
MA 21.7,-7.3
MA 21.4,-6.9
MA 21.3,-6.5
MA 21.2,-5.9
MA 21.3,-5.1
MA 21.5,-4.4
MA 21.8,-3.6
MA 22.2,-3.0
MA 22.6,-2.6
MA 23.1,-2.3
MA 23.6,-2.1
IT off
MUMR 10

//--------- e2 ---------
JA 23.8,-2.8
MUMR -10
IT on
MA 24.4,-2.8
MA 24.7,-2.9
MA 24.8,-3.3
MA 24.9,-3.5
MA 24.8,-3.8
MA 24.5,-4.0
MA 24.1,-4.2
MA 23.5,-4.4
MA 22.5,-4.4
MA 22.6,-3.9
MA 23.1,-3.3
MA 23.5,-2.9
MA 23.8,-2.8
IT off
MUMR 10

//---------- c ---------
SL WITec Logo:  C
JA 29.1,-2.1
MUMR -10
IT on
MA 30.1,-2.1
MA 30.7,-2.2
MA 30.5,-3.1
MA 30.1,-3.0
MA 29.5,-2.9
MA 29.0,-3.0
MA 28.6,-3.2
MA 28.2,-3.5
MA 27.8,-4.2
MA 27.5,-5.2
MA 27.4,-5.7
MA 27.5,-6.2
MA 27.7,-6.5
MA 28.0,-6.7
MA 28.3,-6.8
MA 28.7,-6.9
MA 29.2,-6.8
MA 29.5,-6.7
MA 29.8,-6.6
MA 29.8,-7.4
MA 29.3,-7.6
MA 28.8,-7.7
MA 28.3,-7.7
MA 27.7,-7.7
MA 27.2,-7.4
MA 26.8,-7.1
MA 26.6,-6.6
MA 26.5,-6.2
MA 26.5,-5.5
MA 26.5,-4.8
MA 26.8,-4.2
MA 27.1,-3.4
MA 27.5,-3.0
MA 27.7,-2.8
MA 28.2,-2.4
MA 28.8,-2.2
MA 29.1,-2.1
IT off
MUMR 10

//--- Back To Origin ---
SL Back to Origin
JA 0.0,0.0

//------- Delay --------
SS 0.1
MR 0.1,0
MR -0.1,0

MUMR -10
```