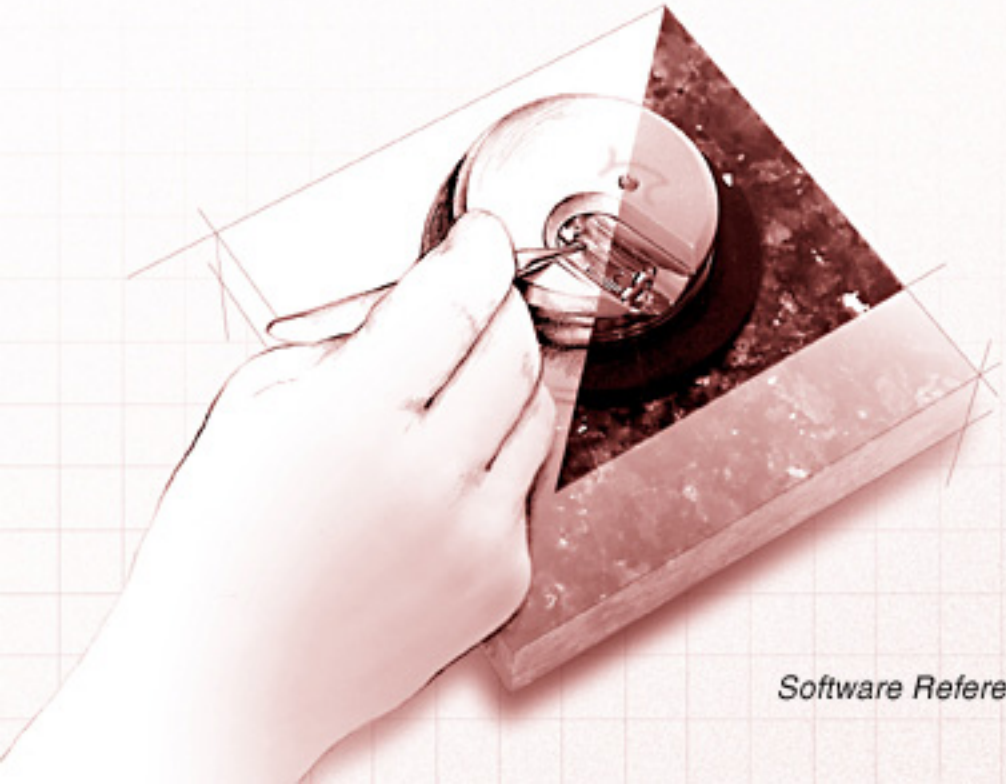
nanoSurf

easyScan

STM SYSTEM



Software Reference

Table of Contents

Introduction

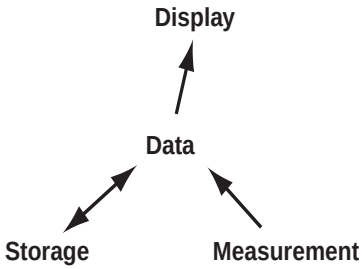
This manual explains the fundamental concepts behind the data acquisition software and how it works together with the scanner and electronics.

First, the software concept is discussed, followed by explanations of each command and parameter.

Concept of easyScan software

The central to the easyScan scanning software is the measured data, which is generated using the microscope and is visualized by the program.

In principle once the data has been measured it is not altered by the program itself.



Only the way the data is represented, can be altered and saved using the 'View Panel'. All settings are dealt with thematically, in so called 'Panels', which are not required to be visible all the time and can be opened on demand.

Measurement

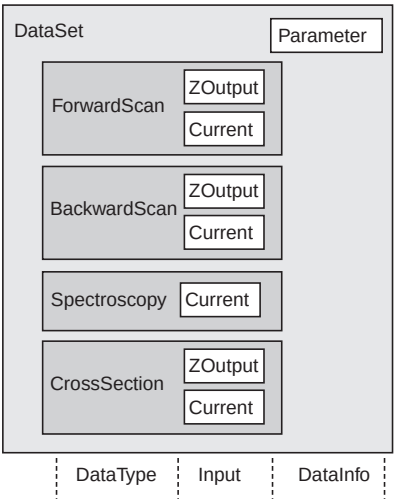
A measurement is defined with the aid of the following panels:

- Scan Panel: generates 'topographical' images.
- SpectroscopyPanel: generates I/V or I/Z curves.
- Feedback Panel: settings for feedback loop parameters.

A measurement can only be performed when the sample is brought close enough to the tip. This is called the approach and is carried out using the 'Approach Panel' where the stepping motor for the sample holder can be controlled.

Storage

Data is generated by a measurement and can be then stored in a permenant memory on the computer. The acquired data is grouped and collected to form the data set of a measurement.



Schematic representation of the data collection of a measurement

Data representation (“Views”)

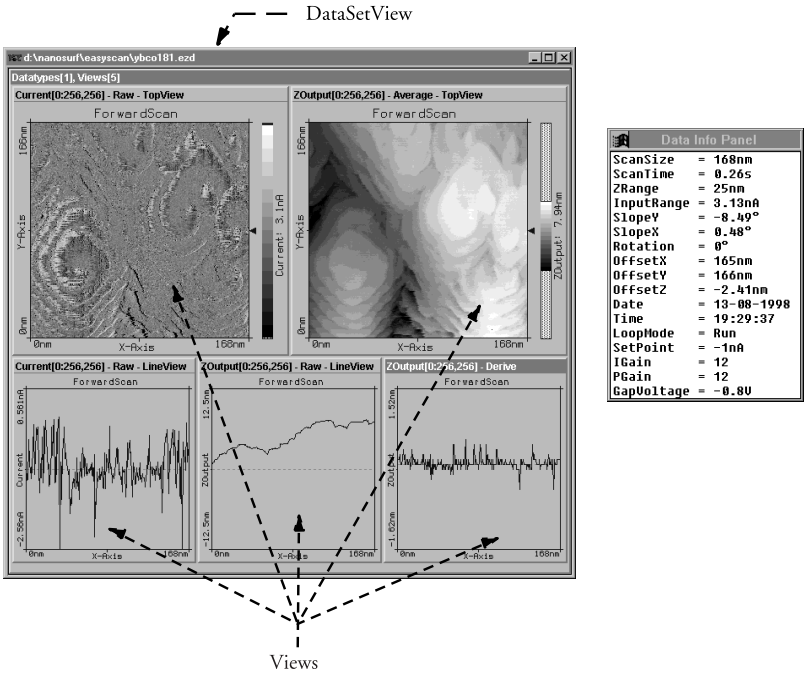
Data sets are displayed in ‘DataSetViews’. These can collect several views of the same data set.

New ‘Views’ are created using the ‘View Panel’.

The program allows the simultaneous display of all measured channels and already processed data (e.g. with plane subtraction) even during data acquisition.

The easyScan software allows individual configuration the way the results (or measurements) are displayed. The configuration can be saved as a ‘workspace’.

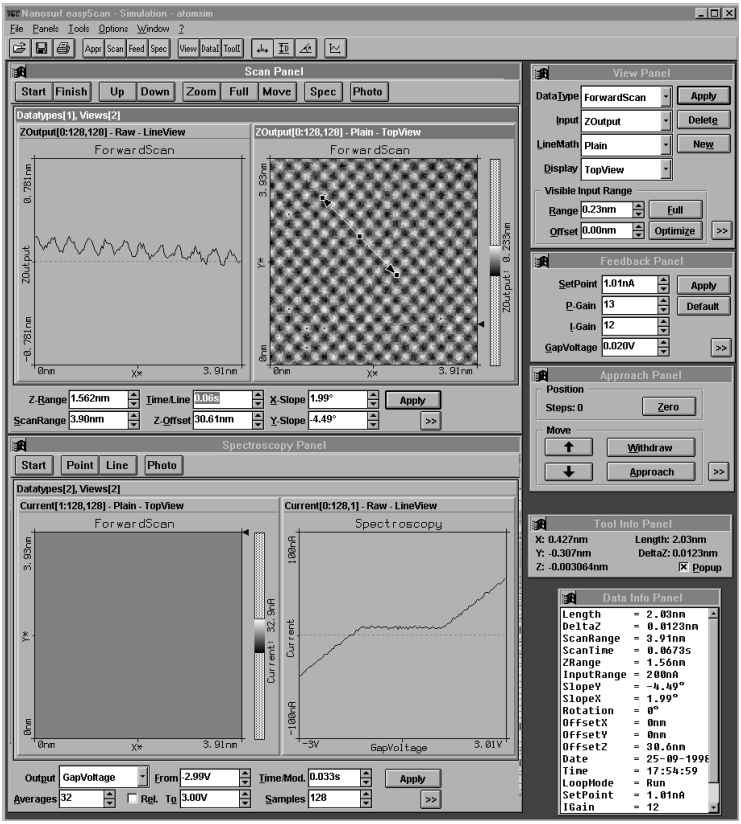
Additional information belonging to a measurement is displayed in the ‘Data Info Panel’.



left: a possible way of displaying a data set with 5 views. right: the Data Info Panel.

The scan software

In this chapter all the special software functions, which are used to control the microscope and visualize the measured data, are described.



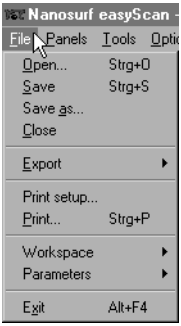
The main window of 'easyScan' with all panels opened.

To understand all parameters in detail it is necessary to have a large knowledge of physics in the area of scanning tunneling microscopy. This cannot be explained here in great detail.

This chapter goes through the functions in each menu consecutively. The most commonly used functions can be accessed through the 'tool bar' below the menu section of the main window.

Menu File

Menu-bar entry 'file' contains the items for opening, closing, saving, printing the data sets and for exiting the program. In the following only the special functions are mentioned.



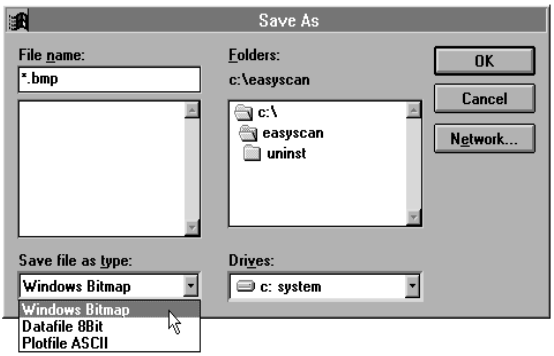
'Save' and 'Save as...'

By 'save' and 'save as...' you can store data sets which have been captured using the Photo button in the easyScan data format (file extension .ezd). Please note that filenames are restricted to 8 characters plus an extension of 3 characters (DOS convention).

You can open such a .ezd file by double clicking with the mouse (in the file manager Win3.1/3.11 or in explorer Win95/98/NT). Automatically the 'easyScan' program is started and the data can be analyzed.

Export ->View as / DataSet as

With these functions either the active view is saved or the whole active data set is saved as a bitmap (.bmp), data file (.dat) or plot file (.plt) for the use in other programs or image processing software (see also chapter 'Programs for further data processing').



Windows Bitmap (.bmp)

A Windows Bitmap image is suitable for including in documents, e.g. word or image processing software . The exact image as seen on the computer screen will be saved in the file ('screen shot').

Data file 8Bit (.dat)

A graphics as binary data file can be processed in image processing software.

This 'binary' data format contains only the measured data. The data is stored consecutively line by line upwards as 8-bit values (0-255). The data is stored using the settings chosen in the 'LineMath' section of the 'View Panel'. If the display mode 'LineView' is selected in the 'View Panel' only the visualized line will be saved.

Plotfile ASCII (.plt)

This is an 'ASCII' text format which contains the measured data as well as a small header with a description of the scan. The data is stored using the setting 'LineMath' of 'View Panel'. A measurement as a plotfile can be used for detailed data analysis by various mathematics software like e.g. MathLab or plotted by GnuPlot.

- If 'LineView' is selected as 'Display' in the 'View Panel', only the vizualized lines will be stored. Each data point is stored as a pair of floating point numbers on a separate line. The number pairs are separated by a blank character (SPACE).
- If 'TopView' is selected as 'Display' in the 'View Panel', then all measured values are stored. Each value of a data line is stored in the text file on a separate line. An empty line is inserted after every data line. The data lines are stored from the bottom to the top. A small header at the beginning of the first data line contains the names of the channel and frame, as well as X-, Y-, and Z-ranges in their logical units.

If the actual data is stored using the function 'Export->DataSet as..' then every 'View' in the data set is stored in the export file consecutively. Whereby the settings as decribed above are used.

With the 'binary' format the blocks of data from each 'View' are stored directly one behind the other.

With the 'ASCII' text format the blocks of data for each 'View' are separated by two empty lines.

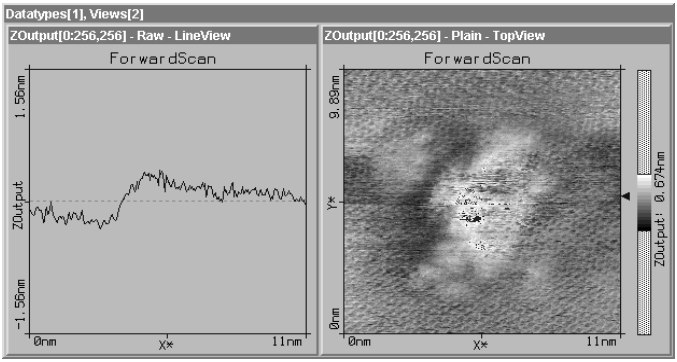
Print

Prints the actual data set together with the values monitored in the 'Data Info Panel'.

The following example shows the printout of a typical measurement. In addition to all the views, further information is provided on the printout:

easyScan STM data

File: c:\easyScan\mos13.ezd



ScanRange	= 11nm	OffsetZ	= 20.7nm
ScanTime	= 0.16s	Date	= 23-09-1998
ZRange	= 3.13nm	Time	= 17:38:41
InputRange	= 3.13nA	LoopMode	= Run
SlopeY	= 6.49°	SetPoint	= 1.69nA
SlopeX	= -5.99°	IGain	= 12
Rotation	= 49.9°	PGain	= 11
OffsetX	= 28.6nm	GapVoltage	= 0.334V
OffsetY	= -4.65nm		

Workspace

When the 'easyScan' program is started some of the panels appear at predefined places on the computer's screen. This arrangement (workspace) is stored in the configuration file 'default.ezw'.

Using '**Save as...**', you can save your own arrangement of the panels under another name if desired.

Using '**Load**', you can load predefined arrangements of the panels.

CAUTION: With '**Save**' you directly overwrite the original configuration file 'default.ezw' with the latest arrangement of the panels.

If the file 'default.ezw' is missing the 'easyScan' main window remains empty after program start. If a panel is opened it opens in the centre of the main window.

Parameters

All the panels numerical parameters are stored by this function. when the program is started default values are loaded which are stored in the file named 'default.ezs'.

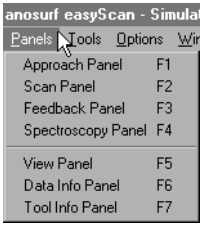
Using '**Save as**', altered settings can be stored under a new filename. These settings can be loaded by '**Load**'.

CAUTION: Using '**Save**', you directly overwrite the original configuration file 'default.ezs' with you actual settings.

If the file 'default.ezs' is missing the program inserts default values for all parameters, suitable for measuring a graphite sample.

Menu Panels

If an entry is selected the appropriate panel is opened in the main window. Panels which are hidden behind other windows or panels are brought into the foreground. A panel can also be opened using its shortcut-key.



The panels can also directly be opened using the buttons of the tool bar:

Most panels contain [>>] buttons which give access to more detailed parameters. Using [>>] the full range of parameters can be seen. [<<] returns the panels to its standard form.

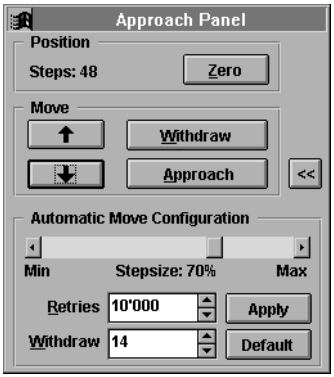
The function of the data entry boxes of 'Panels' is as follows:

- an entered value can be confirmed by using the [Apply] button with the mouse pointer, or by hitting the 'Enter' or 'Return' key on the keyboard.
- altering the value can be done by using the arrow buttons, the mouse, or the cursor key on the keyboard. The new value will automatically be taken on after one second.

Somtimes after entering a value, the program does not accept it and changes it to a slightly different value. This happens when the desired value cannot be performed by the electronics due to the resolution of the analog-digital converter. The desired value is automatically changed to the nearest possible value.

Approach Panel

Sample holder's motor is operated by the 'ApproachPanel'. This is used to obtain a precise and reproducible sample to tip approach.



Position

The Z-position of the motor is monitored by the number of steps performed.

Zero: resets the position counter to zero.

Steps: shows the number of steps taken.

Move

The following four buttons control sample holder's motor:

↑: or 'ctrl.-key' + 'left mouse button', (note, the cursor has to be within the panel): The sample holder is continuously driven away from the scanning tip until the button is released.

↓: or 'ctrl.-key' + 'left mouse button', (note, the cursor has to be within the pane)l: The sample holder is continuously driven towards the scanning tip until the button is released.

Withdraw: retracts the sample from the tip by a predefined number of steps.

Approach: starts the automatic approach of the sample to the tip until the selected tunneling current is detected.

To begin the tip is retracted. The sample is moved one step towards the tip by the piezo motor. The tip is then moved towards the sample until the desired tunneling current is detected. If the current is not detected then the sample is not enough close to the tip. Consequently the tip is retracted again and the sample is moved another step towards the tip.This procedure is repeated until the desired tunneling current flows between tip and sample or the maximum number of steps have been reached. The Z-Offset is reset to zero by starting 'Approach'.

Automatic Move Configuration

Stepsize: The 'Stepsize' of the motor for the automatic approach is adjusted by the slider.

IMPORTANT NOTE: The step size of the piezo motor may vary slightly from device to device and also depends strongly on the friction between slider and the guide bars on which the slider is moved. Therefore keep always both parts clean (ref. "Maintenance" in Introduction Manual). If the automatic approach appears to be to slow, the 'stepsize' may be increased.

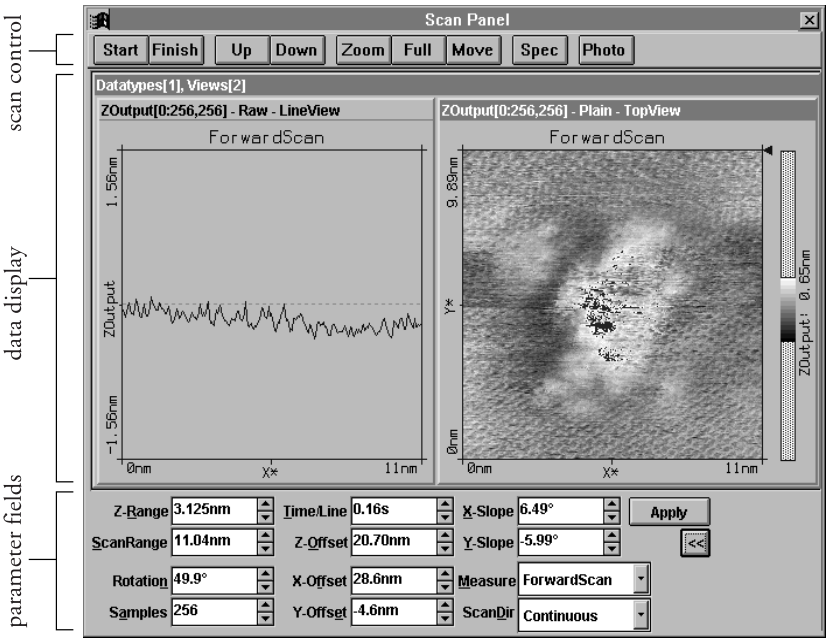
If on the other hand the automatic approach results in a 'tip-crash' (LED on scanner turns 'red') the step size may be reduced since the motor most probably takes too big steps .

Retries: The 'Retries' value defines the maximum number of steps which are performed by the automatic approach and started by the Approach button.

Withdraw: The 'Withdraw' value defines the number of steps which the sample holder is retracted from the tip using the Withdraw button.

Scan Panel

The 'Scan Panel' is the control centre of the instrument. Here the most important measuring parameters are set and the acquired data is displayed.



After starting the program two windows will appear in the centre of the 'Scan Panel', the data will be displayed in these (default setting). The data can be viewed in several ways simultaneously depending on the setting in 'View Panel'.

The 'ScanPanel' can be changed in size. This enables the representation of any number of data views even during scanning. The size of the 'Scan Panel' is changed using the mouse pointer. New views are added to the 'Scan Panel' using the New button of the 'View Panel'. The attributes of the new views are defined using the 'View Panel'.

We recommend having at least two displays, one a section ('Line View') of the scan surface (showing the actual scan line) and one topographical ('Top View').

Start/Stop, Finish, Up, Down

In the upper part of 'ScanPanel' are the buttons to control the scan.

Start/**Stop**: The **Start** button starts a measurement and then changes to **Stop** .This is then used to abort the measurement immediately.

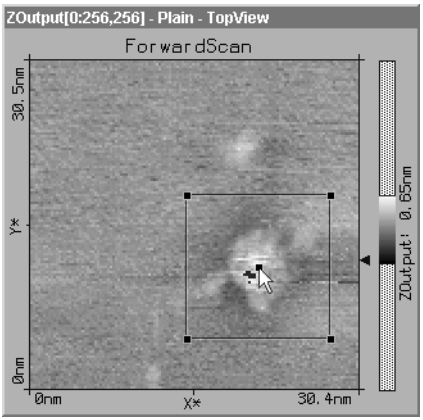
Finish: After using **Finish** the measurement stops when the bottom (or top) of the image has been reached.

Up/**Down**: With the **Up** button the sample is scanned from the bottom to top and with the **Down** button it is scanned from the top to the bottom.

If a scan has been started using **Up** or **Down** the measurement stops automatically after one full image .

Zoom

With the **Zoom** button a smaller area can be looked at in more detail.



By dragging the mouse pointer over an area in a 'TopView' display while holding down the left mouse button this square is defined. Once defined this square can be resized by dragging one of its edges and moved to the desired position by its centre using the mouse. The 'Tool Info Panel' shows the size and position of this new area and the cursor. A double click with left mouse button confirms the new area by modifying the parameters 'ScanRange', 'X-, Y-, Z-Offset' in 'ScanPanel' accordingly . When the zoom function is active it can be aborted either by using the Zoom button again or by clicking with the right mouse button.

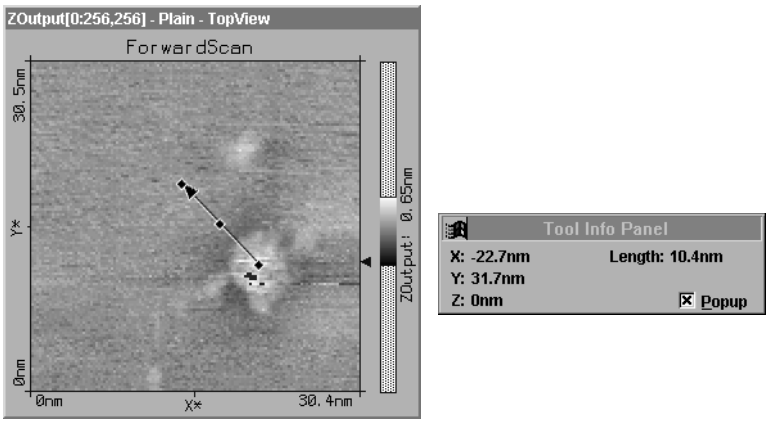
If just a single mouse click is performed in the active 'View', a square 33% of the full area is generated.

Full

By Full the parameters 'ScanRange', 'X-', 'Y-Offset' are set to their largest possible values.

Move

With the Move button you can move the image i.e an interesting corner can be moved to the middle of the picture.



By pressing the left mouse button and dragging the mouse pointer along a line then releasing it an arrow is defined. The arrow head indicates the images new position. A double click with the left mouse button moves the image from its original postion to the newly chosen one.

The move function can be aborted either by using the Move button again or by clicking with the right mouse button.

A single mouse click in the active 'View' produces an arrow from the actual pointer position to the centre of the 'View'.

Spec

By using Spec the current measurement is interrupted and the actual data is transferred to the 'Spectroscopy Panel', which opens automatically.

I/V and I/z experiments are performed using the 'Spectroscopy Panel'

Photo

Photo generates a copy of the image (entire data set) acquired by 'Scan Panel' and displays it in a separate window. The scanning continues automaticaly.

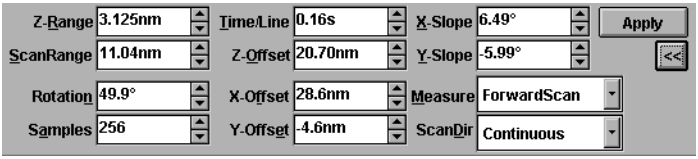
If the Photo button is pressed during the scan the actual frame will be finished before a copy is generated. During the scan the button remains pressed. The photo process is canceled by using the Photo button a second time.

To capture an image without waiting for the full frame to be completed the scanning has to be stopped by using Stop. The image can then be copied using the Photo button.

When leaving the program you will be asked if you want to save the photos. These data sets can be labelled automatically (e.g. DataSet1.ezd) and once nine data sets have been saved, the labels are reduced to 'DSet13.ezd' for example, so as not to exceed the 8 character maximum allowed by this program.

Parameter fields

After starting the program the six most important parameter fields 'Z-Range', 'ScanRange', 'Time/Line', 'Z-Offset', 'X-Slope' and 'Y-Slope' are accessible in 'ScanPanel'. The additional parameter fields 'Rotation', 'Samples', 'X-Offset', 'Y-Offset', 'Measure' and 'ScanDir' are activated by the >> button.

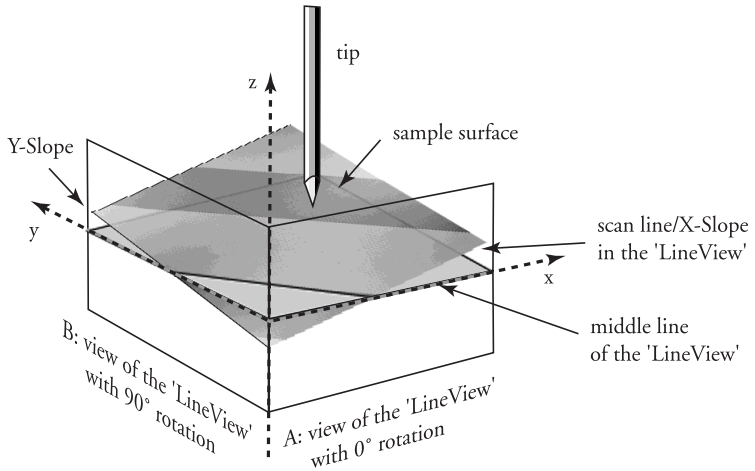


Z-Range: fixes the displayed range in z-direction. For example to be able to observe atomic features on a surface the signal in z-direction has to be amplified. This is achieved by diminishing the 'Z-Range'.

ScanRange: fixes the scan size in x and y direction [nm] where (x=y). The value is doubled or halved when using .

Time/Line: sets the time taken to acquire a data line.

By using the next three parameters, the plane on which the tip is scanned (scan-plane) and the surface of the sample are aligned (see also schematics):



Z-Offset: raises the scan-plane in z-direction [nm].

X-slope: tilts the x-axis of the scan-plane counterclockwise.

Y-slope: tilts the y-axis of the scan-plane counterclockwise (when viewed at 90° rotation).

With the help of these alignements the performance of the feedback circuit can be optimized so that only deviations from this inclined scan-plane have to be compensated. Therefore a much better resolution is achieved.

Rotation: rotates the scanned area clockwise by the given angle.

Samples: sets the number of measured datapoints per line.

By changing the X-/Y-Offsets the scanned area can be shifted. The values are always relative to the centre of the entire scan range:

X-Offset: sets displacement of the measured area in x-direction [nm].

Y-Offset: sets displacement of the measured area in y-direction [nm].

Measure: one of the options 'Backward', 'Forward' or 'Forw. & Backw.' can be chosen.

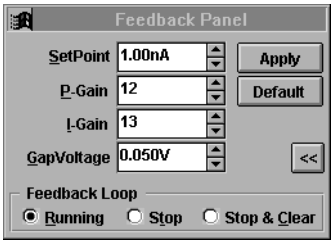
- 'Forward': only data during forward scan is acquired and stored.
- 'Backward': only data during backward scan is acquired and stored
- 'Forw.&Backw.': data during forward and backward scan is acquired and stored

ScanDir: one of the options 'Continuous', 'Cont.Up' or 'Cont. Down' can be selected:

- 'Continuous': The measured image is displayed from bottom to top and vice versa.
- 'Cont.Up': The image is displayed from bottom to top.
- 'Cont.Down': The image is displayed from top to bottom.

Feedback Panel

To scan the tip across the sample's surface the distance between tip and sample must be controlled. For example in Scanning Tunneling Microscopy the control parameter is the tunneling current.



***Feedback Panel** - Setting the measuring and feedback loop parameters*

The parameters of the feedback loop and the tunneling current are set by the items in 'Feedback Panel':

SetPoint: sets the tunneling current [nA].

P-Gain: sets the proportional feedback value.

I-Gain: sets the integral feedback value of the z-distance controller.

If both P-gain and I-gain are set to 0, the feedback loop is switched off. when P-gain or I-gain are set to 16, it has maximum proportional gain or integrator speed.

GapVoltage: sets the voltage of the tunneling gap between tip and sample [V]. A positive 'GapVoltage' means that the tip has a positive potential relative to the sample's surface and hence the electrons tunnel from the sample to the scanning tip.

Default: restores the default values for graphite experiments.

Feedback Loop

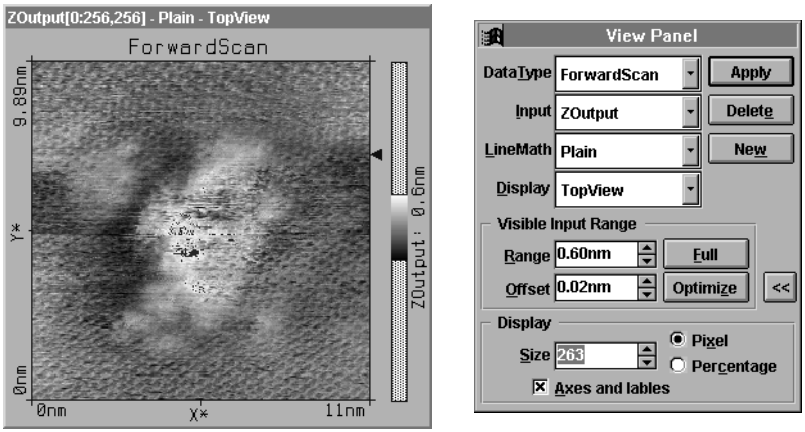
Running: the feedback loop of the Z-distance controller is active.

Stop: turns off the Z-distance controller. The tip is fixed in the actual Z-position relative to the scan-plane defined by X- and Y-Slope.

Stop & Clear: turns off the Z-distance controller. The tip's Z-position is set to the actual 'Z-Offset' position relative to the scan-plane defined by X- and Y-Slope. Increased tip crash danger.

View Panel

The way the data is represented in a 'View' can be controlled by the 'View Panel' attributes. The setting always refers to the actual active view in the data display. It is possible to show the same data in different ways using the 'View Panel' settings.



ViewPanel - setting of the view parameters

DataType: depending on what is being measured or was saved in a data set, the results and how they are shown can be choosen here: 'ForwardScan', 'BackwardScan', 'Spectroscopy' or 'CrossSection'.

Input: indicates which data input is displayed:

- 'ZOutput': tracks the movement of the z-Piezo [nm].
- 'Current': monitors the tunneling current [pA].

LineMath: defines processing of data before it is displayed:

- 'Raw': raw data without any processing.
- 'Average': an average is subtracted from data points.
- 'Plain': an inclined plain is subtracted from data.

- 'Derive': difference between two successive datapoints (derivative).

Display: sets the display mode:

- 'LineView': data is displayed as x-z diagram (->contour line).
- 'TopView': data is encoded in gray scale values in x-y plane (-> 'topography').

When selecting the display mode 'LineView' the Z-Range is automatically set to full range.

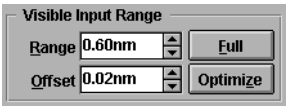
Apply: applies the actualized settings to the active 'View'.

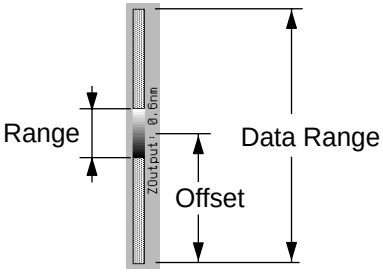
New: creates an additional display of the active data set, using the settings in the 'View Panel'. Eventually the 'Scan Panel' has to be resized to see all 'Views'.

Delete: removes the active display.

Visible Input Range:

The grey scale of an image is controlled by the settings in the 'Visible Input Range' section. The actual greyscale is represented as color-bar in the appropriate 'Top View' window.





Range: affects the 'contrast' of the image.

Offset: affects the 'brightness' of the image.

Optimize : the software tries to find the optimum range and offset for the active image using a histogram of the images' colors.

Full : expands the color table to the full input range.

Display:

The appearance of a 'View' is controlled by the attributes in the 'Display' section:

Size: the size of the active view is defined by the value of 'Size'.

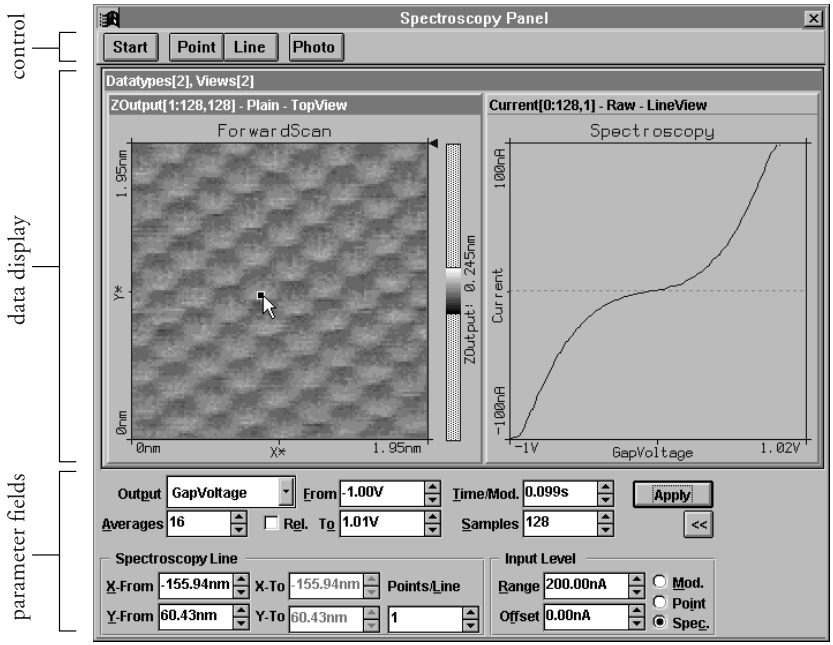
Pixel: If selected then the value in 'Size' indicates the image size in pixels. The number of pixels should be an integer multiple of the value 'Samples' (measured points) in 'Scan Panel' or 'Spectroscopy Panel' in order to avoid interpolation which could lead to imaging faults (Moiré pattern)

Percentage: If selected then the value in 'Size' indicates the number of pixels per measured point in percent: recommended is 100%, 200% or 300%.

Axes and labels: With this check box the labels in 'Views' and the grey scale bar in 'TopView' window, can be switched on and off.

Spectroscopy Panel

Current/Voltage (I/V) or Current/Z-distance (I/Z) characteristics can be obtained using the 'Spectroscopy Panel'.



The 'Spectroscopy Panel' is divided in three parts: On the top are buttons which control the measurement, in the middle, data is displayed and on the bottom parameter fields allow the extended definition of the measurements.

When 'Spectroscopy Panel' is activated from 'Scan Panel', the latest measured image is transferred to 'Spectroscopy Panel'. If activated using the menu item or the function key 'F4' or the button Spec of the tool bar then the panel is opened without data transfer.

Start/Stop

The Start button starts a measurement. This changes immediately to Stop with which the measurement can be interrupted at once.

The measurement is carried out in the following way:

1. The tip is moved with active feedback to the defined start.
2. The feedback loop is switched off.
3. The spectra are recorded (I/V or I/Z).
4. The feedback loop is turned on again.

(If a line was defined the tip is moved to the next point on the line and then steps 2.-5. are repeated according to the number of points on the line.)

5. The tip is moved to the next point.

Point/Line

Using buttons Point and Line the coordinates of the points where a spectrum is to be taken are defined easily by the mouse.

If a 'TopView' window is selected a point (hit Point) or line (hit Line) can be drawn using the mouse pointer. Clicking only once with the right mouse button generates a small square (point) or arrow (line) pointing to the centre of the view.

When Line is selected an arrow can be drawn by clicking and dragging with the mouse. After marking the coordinates they are transferred by double clicking the right mouse button to the apropriate fields in the lower part of the 'Spectroscopy Panel'.

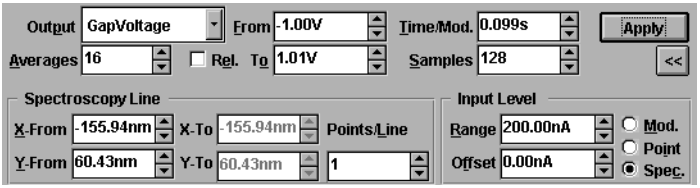
Clicking with the left mouse button aborts the function.

Photo

Photo generates a copy of the data set (image and data) which now also contains spectroscopic data. i.e. besides 'Forward' and 'Backward' scan 'Spectroscopy' also appears as 'Datatype' in 'View Panel'.

Parameter fields

If only some of the parameter fields are visible, the 'Spectroscopy Panel' can be extended by using the [>>] button.



Output: In the selection box 'Output' the item 'GapVoltage' or 'Z-Axis' can be chosen. The selected output will vary according to the configuration of the spectroscopy measurement.

Averages: Sets the number of times the measurement is repeated at a data point. The measurement is then averaged arithmetically.

Rel. If this check box is selected the 'Output' is varied relative to the actual value of 'GapVoltage' or 'Z-Position' respectively.

From/To: When mesuring a point the 'Output' varies between the values set by 'From' and 'To' (beginning at 'From')

Time/Mod.: This field sets the duration of a single measurement e.g. one I/V curve. Within this time the 'Output' is varied between 'From' and 'To'.

Samples: In this field the number of steps by which the 'Output' is divided (between 'From' and 'To), can be choosen.

Spectroscopy Line:

X-From/Y-From: In a [Point]-spectroscopy these two values correspond to the X,Y-coordinates of the measured point. If a [Line] spectroscopy is being performed these two entries are the coordinates of the first point to be measured in the direction of the arrow.

X-To/Y-To: In a Line-spectroscopy these two values correspond to the coordinates of the last point to be measured of the line i.e. the arrow head. In a Point-spectroscopy these values are not used.

Points/Line: This value sets the number of points to be measured along a Line-spectroscopy.

Input Level:

Using the value of 'Input Level' the range of the measured value can be restricted. If the tunneling current surpasses this range the measurement is interrupted for safety reasons.

Range: Sets the maximum range of the tunneling current.

Offset: Moves the zero level of the abort criteria.

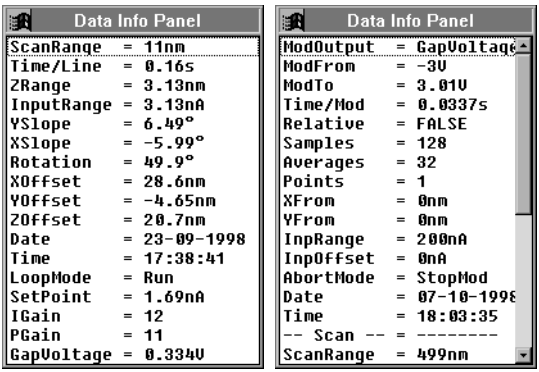
Mod./Point/Spec.: These switches define what is to be done if the 'Input Level' is surpassed and the measurement aborted:

- 'Mod' - aborts only the measurement of the latest diagram and repeats the measurement until the number of retries in 'Averages' is reached.
- 'Point' - aborts the measurement (and all 'Averages') of the latest measured point and continues if a Line spectroscopy is performed with the next point of the line.
- 'Spec.' - aborts the entire spectroscopy measurement (cancels all 'Averages' and points).

If the abort criteria have been reached during the spectroscopy measurement this is reported in 'DataInfoPanel' by ModAborted=(number of aborts) and in 'Spectroscopy Panel' a warning  turns up.

Data Info Panel

'Data Info Panel' displays the parameter of the active measurement. After Loading a measurement by 'File->Open...' a 'Data Display' appears showing the measurement. 'Data Displays' are configured with 'View Panel' and a list of the measurement's parameters are viewed by 'Data Info Panel'.



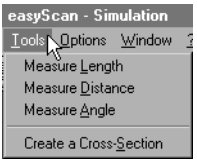
In the left image the parameters of a measurement are shown in the 'Data Info Panel'. In the right image data of a spectroscopic measurement is added to the parameterlist.

Tool Info Panel

The 'Tool Info Panel' monitors the X-/Y-/Z-mouse coordinates in the scan-coordinate system and a size corresponding to the respective function (zoom, move, length-, distance- and measure angle, line section) which is being performed.

If the PopUp-checkbox is activated the PositionPanel is only visible while a function is performed which needs coordinates displayed (e. g. zoom).

Menu Tools

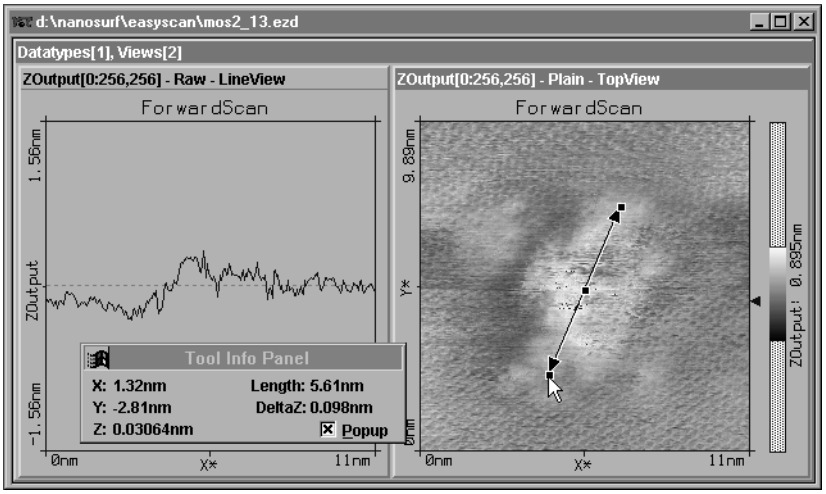


Using these tools the images can be measured. The tools are activated through the corresponding menu item or by the respective button in the tool bar.

All tools can be used in each view during measurement or offline to analyze the data.

Measure Length

Using the 'Measure Length' tool you can define two points in order to analyze the distance between them which is monitored in the 'Tool Info Panel'.



- Activate the image to be analyzed by clicking onto it with the mouse and pushing the button or the menu entry respectively.

- A double ended arrow can be drawn on the data display by holding down left mouse button and dragging the mouse. The length of the arrow is shown in 'Tool Info Panel'.

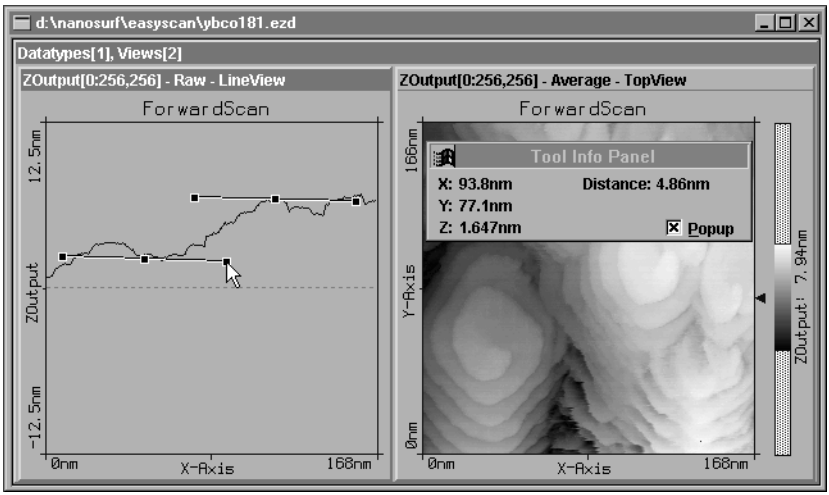
The arrow can be adjusted by using the markings at each end and moved with the middle point.

Clicking without dragging generates an arrow from the actual point to the centre of the image.

The length measurement is aborted by the right mouse button or by pushing the -button a second time.

Measure Distance

Using the 'Measure Distance' tool you can define two parallel lines in order to analyze the distance between them. This is monitored in the 'Tool Info Panel'.



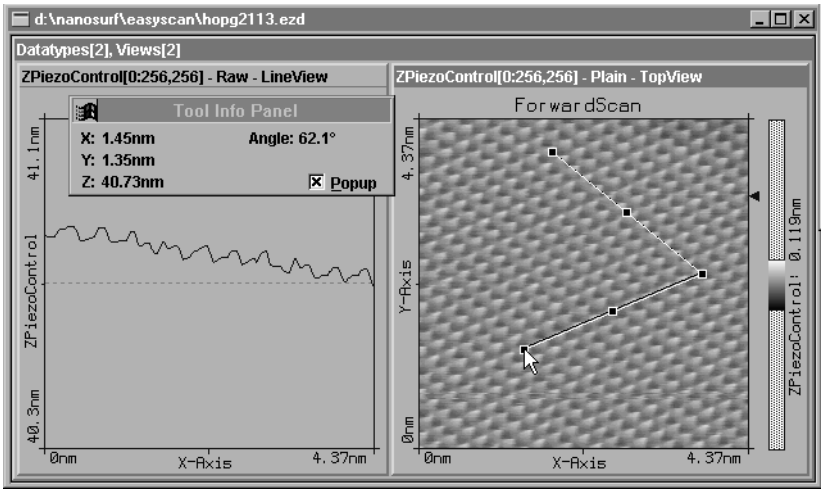
- Activate the image to be analyzed by clicking onto it with the mouse and push the button or select the menu entry respectively.

- A line can be drawn into the data display by holding down left mouse button dragging with the mouse.
- After releasing the left mouse button a parallel line sticks to the mouse pointer and is ready to be positioned. The distance between the two parallel lines is monitored by the 'Tool Info Panel'.
- The second parallel line can be released by clicking with the left mouse button. Both parallel lines can be adjusted by means the handles at their end and translated by the middle handle.

The distance measurement is aborted by the right mouse button or by pushing the -button a second time.

Measure Angle

Using the 'Measure Angle' tool you can draw an angle which is to be analyzed. The size of the angle drawn is monitored in the 'Tool Info Panel'.



- Activate the image to be analyzed by clicking into it with the mouse and push the button or select the menu entry respectively.

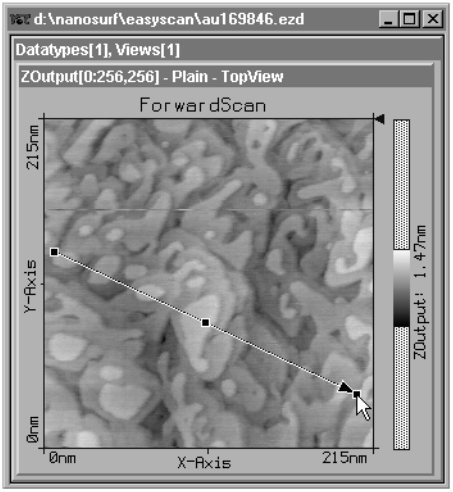
- An angle can be drawn onto the active data display by clicking and dragging with the mouse pointer. The corresponding size and position of the angle is monitored by the 'Tool Info Panel'.

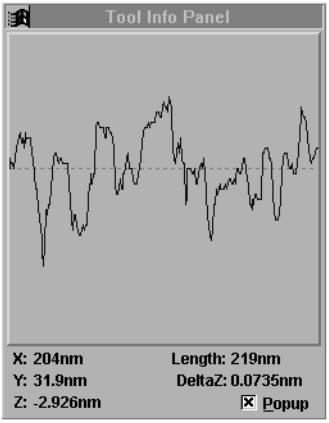
Both sides can be adjusted using the markings. The entire object can be moved using the middle point.

The angle measurement is aborted by using the right mouse button or by pushing the -button a second time.

Create a Cross-Section

The 'Create a Cross-Section' tool enables you to view any cross-section of the 'TopView'. This cross section is monitored simultaneously in the 'Tool Info Panel' and represents a new data set (DataType: CrossSection) when stored.





- Activate the image to be analyzed by clicking into it with the mouse and push the button or select the menu entry respectively.

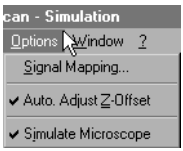
- Define a line with the  tool, by clicking and dragging while holding down the left mouse button. The arrow tip at the end of the cross-section indicates the direction of the cross-section.

The arrow can be modified in position, size and orientation after releasing left mouse button.

Simultaneously with the application of the  tool the actual cross-section is displayed in the 'Tool Info Panel'. The values for 'DeltaZ' and length of the cross-section are also displayed in the 'Data Info Panel'.

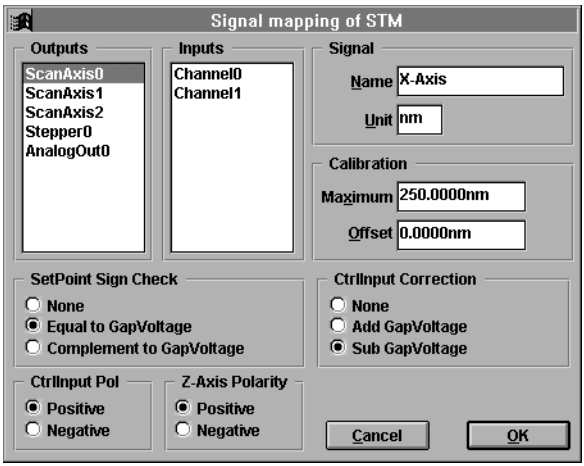
A double click of the left mouse button in the 'TopView' window stores the cross-section in a separate data set. The right mouse button or the application of  cancels this action.

Menu Options



'Signal Mapping'

In this window the units of all Inputs and Outputs can be configurated individually along with the feedback loop's properties which can be adopted to the scan-head.



WARNING! Changes on these settings should be performed with great care. False settings can lead to false interpretation of the data and false operation of the controller.

Outputs/Inputs/Signal

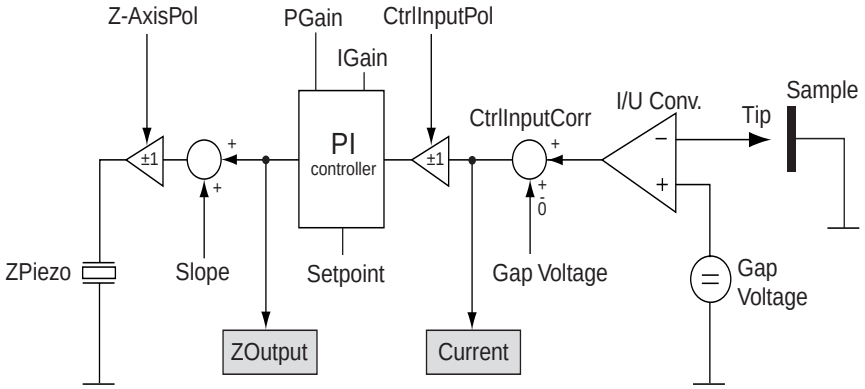
On the right half of the window the available signals are listed. In the field 'Signal' a 'Name' and a 'Unit' is assigned to each Input and Output. These names along with their units are used by the program wherever the signals are displayed.

Calibration

The 'Calibration' values indicate the maximum input and output range of the respective parameters and are used to calibrate the respective inputs and outputs. 'Maximum' is set for the positive range of the value, e.g. for a scan range of 500nm a 'maximum' of 250nm (+250nm,-250nm) must be set. 'Offset' is the difference in value relative to zero.

In the lower half of the window are the settings which enables the controller's setting to be adopted so that the measurement system can be used with different scan-heads.

The following diagram shows the signal flow and where the settings take effect.



SetPoint Sign Check

The sign (+/-) of the 'SetPoint' is adjusred to the sign (+/-) of 'GapVoltage':

none: sign of 'SetPoint' and 'GapVoltage' are independent.

Equal to GapVoltage: 'SetPoint' adopts the sign of 'GapVoltage'.

Complement to GapVoltage: 'SetPoint' adopts the opposite polarity of 'GapVoltage'.

CtrlInput correction

Before the input signal is measured the voltage 'AnalogOut0' (with the STM AnalogOut0=GapVoltage) is mixed with the input signal.

none: the voltage from the scan head's preamplifier is not changed.

Add GapVoltage: 'AnalogOut0' is added to the output voltage of the scan-head's preamplifier.

Sub GapVoltage: 'AnalogOut0' is subtracted from the output voltage of the scan-head's preamplifier.

CtrlInput pol.

Before the measured signal is passed to the PI-controller it can be inverted. If this is necessary depends the type of scan-head.

positive: the signal remains unchanged.

negative: the signal is inverted.

Z-Axis polarity

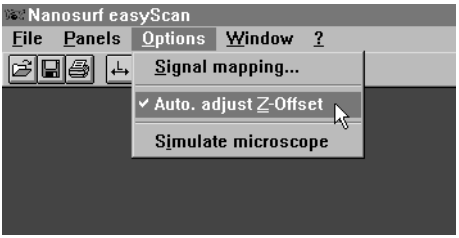
The output of the feedback loop can be inverted before the alignement of the scan plane and output to the 'ScanAxis2' (with the STM Z-axis).

positive: the signal remains unchanged.

negative: the signal is inverted.

Auto Adjust Z-Offset

This option is switched on by default. It alters the value of the Z-Offset so that the signal is always displayed at an optimum range.



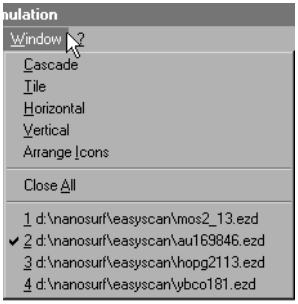
Simulate microscope

Using this item a microscope simulation can be switched on, where most functions of the real microscope are implemented. The sample is replaced by a calculated mathematical model of a surface. Here the whole functionality and working methods of the scanning tunneling microscope as needed for real samples can be practised.

If the program is started without a microscope connected (or powered) the following dialog appears:

By selecting 'Cancel' the microscope simulation is automatically turned on. In this case, in the title bar of the program, the word 'Simulation' is added.

Menu 'Window'



Select the display mode for the 'photographed' measurements.

Menu '?'

'Info...'

In the 'About...'-window you find the software version as well as the serial number of the connected scan electronics.

If the microscope simulation is active 'SerialNr. 000-00-000' is reported. Furthermore you find the adress of the Nanosurf WWW-site where you can find information and software updates.

Programs for further data processing

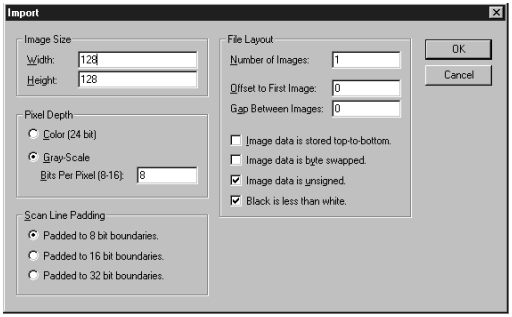
To import the easyScan images into the following freeware programs first export the desired images by 'File->Export->View as...' and select as data type 'Datafile 8-Bit'.

The following programs are available in the internet under their indicated adresses:

PC: 'Image Tool' source: http://ddsdx.uthscsa.edu

Import your data using 'File->Import'. Fill in the 'Import'-dialog' field 'ImageSize' the correct number of points measured. Choose for 'PixelDepth': 'Greyscale 8-Bit' and for 'Scan Line Padding': 'Padded to 8 Bit boundaries'.

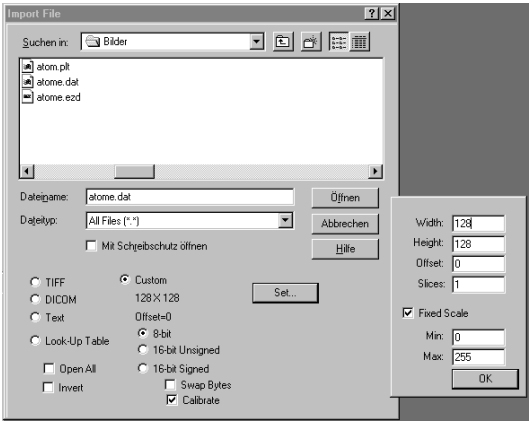
Import your data using 'File->Import'. Enter in 'Import'-dialog under 'Set...' the correct number of measured points (s. example below). Set the data type to 'Custom', '8-Bit'.



Import dialog of 'Image Tool'

PC: 'Scion Image' source: http://www.scioncorp.com

Import your data using 'File->Import'. Enter in 'Import'-dialog under 'Set...' the correct number of measured points (s. example below). Set the data type to 'Custom', '8-Bit'.



Import dialog of 'Scion Image'

Mac: 'ImageSXM' (equivalent to 'Scion Image') source: all info-mac archives as e.g.: ftp://src.doc.ic.ac.uk/packages/info-mac/gst/grf/image-sxm-161-8.hqx

Principles of measurement

Measuring in „Constant Height“ or „Constant Current“ mode

The surface can be scanned in two different ways: in the ‘Constant current’ (CC) and ‘Constant height’ (CH) mode:

In the CC-mode (default setting) the tunneling current is kept constant by the feedback loop and the movements of the tip by the z-piezo are recorded. This ‘height profile’ is displayed in a ‘LineView’ and the ‘topographic’ image is displayed as a grey scale coded ‘TopView’. The tunneling current is not only dependent on the real topography but also on the local density of the electrons.This fact has to be considered when analyzing the recorded images: the images are always superimposed and the electronic structure of the surface.

In CH-mode the scanning tip does not follow the samples corrugation.This time the strength of the tunneling current is measured. This can be achieved by turning the feedback loop off. But then no thermal drifts in Z-direction can be compensated for and tip crashes can not always be avoided. This problem can be avoided by setting the feedback parameters to very low values (1 or 2) so that the feedback loop can follow the slow movements (caused by thermal drift) of the sample. These are very small compared to the sample’s corrugations . To measure in CH mode:

- set P-Gain to 0 and I-Gain to 2 in ‘Feedback Panel’.
- apply these new values by using 

.
- to visualize the current information, in ‘ViewPanel’ chose as input ‘TunnelingCurrent’ and apply these setting using 

.

Notice that now the ‘Z-Range’ is labeled ‘nA’ instead of ‘nm’.

- when displaying a ‘TopView’ image, use in ‘ViewPanel’, ‘Visible Input Range’ 

in order to enhance the image’s contrast.

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Index

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Z

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