



Operating Instructions

easyScan 2 AFM

Version 1.6

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About this Manual

This manual is divided in two parts, the first part gives instructions on how to set up and use your Nanosurf easyScan 2 AFM system. The second part is a reference for the Nanosurf easyScan 2 Control Software. It applies to software version 1.6. If you are using a newer software version, try to download a newer version of the manual from the Nanosurf support pages, or refer to the 'Whats new' file that is installed in the Manuals subdirectory of the directory where the easyScan 2 software is installed.

The first part of the manual starts with the chapter *Installing the easyScan 2 AFM*, which should be read when installing your easyScan 2 AFM system. The chapters *Preparing for Measurement* and *A First Measurement* should be read by all users, because they contain useful instructions for everyday measurements. The other chapters give more information for advanced or interested users.

The second part of the manual starts with chapter *The user interface* (p.87). This part is a description of the function of the buttons and inputs in the dialogs and control panels of the easyScan Control software. Chapter *Quick Reference* (p.162) gives links to the description of each Control Panel, Dialog, Menu item and Operating Window.

For more information on the optional Scripting interface, refer to the on-line help file *easyScan 2 Programmers Manual*, that is installed together with the easyScan 2 software.

For more information on the optional Nanosurf Report software, refer to the on-line help, included with the Nanosurf Report software.

The easyScan 2 AFM

The Nanosurf easyScan 2 AFM is an atomic force microscope system that can make nanometer scale resolution measurements of topography and several other properties of a sample. The easyScan 2 AFM system is a modular scanning probe system that can be upgraded to obtain more measurement capabilities. The main parts of the basic system are the easyScan 2 AFM scan head, the AFM Sample stage, the easyScan 2 Controller with AFM Basic module, and the easyScan 2 software. At the time of publication, the following parts can be used with the easyScan 2 system:

- STM Scan Head: makes atomic scale measurements. Refer to the *easyScan 2 STM Operating Instructions* for more details.
- AFM Dynamic Module: adds dynamic mode measurement capabilities for measuring delicate samples.
- AFM Mode Extension Module: adds phase contrast, force modulation and current measurement capabilities.
- AFM Video Module: allows observation of the approach on the computer screen. This is especially useful when observation using the lenses is impractical.
- Signal Modules: allow monitoring signals (Module: S) and creating custom measurement modes (Module: A). Refer to chapter *The Signal Modules* (p.72) for more details.
- Micrometre Translation Stage: for reproducibly finding a specific position on the sample.
- Nanosurf Report: software for simple automatic evaluation and reporting of surface measurements.
- Nanosurf Analysis: software for detailed analysis of scanning probe measurements.
- Scripting Interface: software for automating measurements. Refer to chapter *Automating measurement tasks* (p.156) and the *Programmer's Manual* for more details.

- TS-150 active vibration isolation table: reduces the sensitivity of the instrument to vibrations in its environment.

Features

easyScan 2 Controller

Electronics

Controller size / weight	470x120x80 mm / 2.4 kg
Power supply	90 - 240 V~/ 30 W 50/60 Hz
Computer interface	(Appr. controller serial number 23-06-030 and higher)
Integrated USB hub	2 Ports (100mA max)
Scan generator	16 bit D/A converter for all axes
Scan speed	Up to 60ms/line at 128 datapoints/line
Scan drive signals	± 10 V, no high voltage
Measurement channels	16bit A/D converters, up to seven signals depending on mode.
Scan area and data points	Individual width/height, up to 2048 x 2048 points
Scan image rotation	0 - 360°
Sample tilt compensation	Hardware X/Y-slope compensation
Spectroscopy modes	Single point measurement or multiple measurements along vector
Spectroscopy measurement averaging	1 - 1024 times
Spectroscopy data points	Up to 2048

Control Software

Simultaneous display of data in charts types	Line graph, Color map, 3D view, ...
User profiles	Customisable display and parameter settings

Simultaneous display of data in charts types	Line graph, Color map, 3D view, ...
On-line processing functions	Mean fit, Polynomial fit, Derived data, ...
Quick evaluation functions	distance, angle, cross section, roughness, ...
Data export	BMP, ASCII, CSV, ...

Nanosurf easyScan 2 Scripting Interface

Applications	Automating measurement tasks, lithography, custom evaluation functions, using third party measurement equipment
Included control software	Windows Scripting Host: Visual Basic Script, Java Script, ...
Remote control by	COM compatible languages: LabView, MathLab, Visual Basic, Delphi, C++, ...

Computer requirements

Operating system requirement	Windows 2000, XP, Vista
Electronics interface	USB port
Recommended PC hardware	Pentium 4/M or AMD Athlon, 256MB RAM, True color > 1024x786 video card, HW Open GL accelerator

Computer not included with system.

Nanosurf easyScan 2 Signal Module: S

Available output signals	X-Axis, Y-Axis, Z-Axis, Approach, Tip Voltage, STM Current or AFM Deflection, Excitation, Amplitude, Phase
Full scale corresponds to	± 10 V, Excitation: ± 5 V
Power supply output	GND, +15 V, -15 V

Nanosurf easyScan 2 Signal Module: A

Output signal	All output signals of Signal Module: S
---------------	--

Additional analog user outputs	2x 16 bit D/A converters, ± 10 V
Synchronisation output	1x TTL: start, end, point sync
Additional signal modulation inputs	X-Axis, Y-Axis, Z-Axis, Tip Voltage, Excitation
Free connectors	2x Aux, connection made on user request
Modulation range	± 10 V, Excitation: ± 5 V
Additional analog user inputs	2x 16 bit A/D converters, ± 10 V
Additional modes	Almost unlimited

User inputs can optionally be measured in all Imaging and Spectroscopy modes.

User outputs can be modulated in Spectroscopy measurements.

Scan Heads

AFM Scan Head:	10 μm	70 μm	110 μm
Maximum Scan range ¹⁾	10 μm	70 μm	110 μm
Maximum Z-range	2 μm	14 μm	22 μm
Drive resolution Z ²⁾	0.027 nm	0.21 nm	0.34 nm
Drive resolution XY ²⁾	0.15 nm	1.1 nm	1.7 nm
XY-Linearity Mean Error	<0.6%	<1.2%	<0.6%
Z measurement noise level (RMS, Static Mode)	0.07 nm (max. 0.2 nm)	0.6 nm (max. 0.8 nm)	0.4 nm (max. 0.55 nm)
Z measurement noise level (RMS, Dynamic Mode)	0.04 nm (max. 0.07 nm)	0.5 nm (max. 0.8 nm)	0.3 nm (max. 0.55 nm)

1) Manufacturing tolerances are ± 15 % for 10 μm and 70 μm heads, ± 10 % for 110 μm scan heads. The exact values are given on the calibration certificate delivered with the instrument.

2) Calculated by dividing the maximum range by 16 bits

Scanner features

Design Tripod stand-alone

Sample size	Unlimited
Automatic approach range	5 mm
Max. approach speed	0.1 mm/s
Alignment of cantilever	Automatic adjustment
Electrical connection to tip	Available
Scan head weight	350 g
Sample observation optics	Dual lens system (top/side view)
Optical magnification	Top x12 / side x10
View field	Top 4x4 mm / side 5x3 mm
Sample illumination	White LEDs sideways illumination, adjustable brightness

Compatible cantilevers

Manufacturers	NanoSensors® and NanoWorld®	Applied Nanostructures
Static modes	CONTR, LFMR, ZEILR	SICONA
Dynamic modes	NCLR, ZEIHR, EFM, MFMR	ACLA, MAGT, FORTA
Spreading Resistance mode	CONTPt, NCLPt, CDT-NCLR	ANSCM-PC, ANSCM-PT
Available tips	Standard, SuperSharp Silicon, HighAspectRatio, Diamond	Rotated pyramidal (standard)
Typical static load	10 nN	

Measurement modes

AFM Basic Module

Imaging modes	Static Force (Contact): Const. Force (Topography), Const. Height (Deflection)
Spectroscopy modes	Force-Distance, Force-Tip voltage
Tip voltage	±10 V in 5 mV steps

The AFM Basic Module is required for using AFM Scan Heads.

AFM Dynamic Module

Additional imaging modes Dynamic Force (Intermittent Contact, etc.): Const. Amplitude (Topography), Const. Height (Amplitude)

Additional spectroscopy modes Amplitude-Distance

Dynamic frequency range 15kHz - 300kHz

Dynamic frequency resolution < 0.1Hz

The AFM Basic Module is required for using the AFM Dynamic Module.

AFM Mode Extension Module

Additional imaging modes Phase Contrast, Force Modulation, Spreading Resistance

Additional spectroscopy modes Phase-Distance, Current-Voltage, Current-Distance etc.

Phase contrast range $\pm 90^\circ$

Phase contrast resolution < 0.05°

Phase reference range 0 - 360°

Tip current measurement $\pm 100\mu\text{A}$, 3nA resolution

Both the AFM Basic Module and the AFM Dynamic Module are required for using the AFM Mode Extension Module.

AFM Video Module

Camera system Dual video (top/side view)

Magnification Top: 100x / side: 70x

View field Top: 3.2x2.7 mm / side: 4.1x3.4 mm

Image pixels 352x288

Video display In control software, can be saved as JPEG

Analog video output PAL Video-S

Additional sample illumination Version 2 video cameras: constant axial illumination for top view

Micrometre Translation Stage

X-Y resolution < 0.5 μm

Travel

13 mm

Components of the System

This section describes the parts that may be delivered with an easyScan 2 AFM system. The contents of delivery can vary from system to system, depending on which parts were ordered. To find out which parts are included in your system, refer to the delivery note shipped with your system. Some of modules listed in the delivery note are built into the Controller. Their presence is indicated by the status lights on the top surface of the Controller when it is turned on (section *Connectors, Indicators and Controls* (p.18)).



Components: The easyScan 2 AFM system

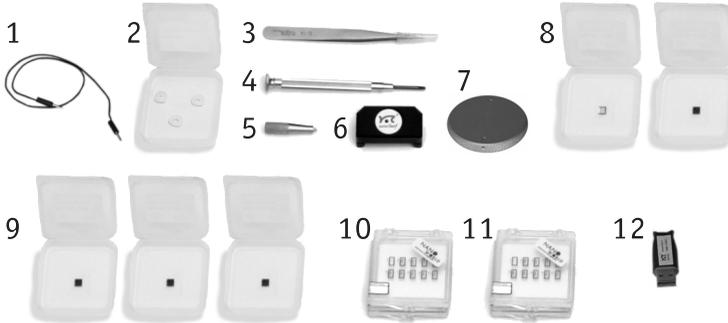
1. easyScan 2 Controller with a built in AFM Basic Module, and optionally with built in AFM Dynamic Module, AFM Mode Extension Module, Video Module electronics and Signal Module A or S electronics

2. USB cable
3. Mains cable
4. easyScan 2 AFM Scan head(s) with AFM Video Camera (with AFM Video Module)
5. Scan head case
6. Scan head cable
7. Video Camera cable (with AFM Video Module)
8. AFM calibration certificate
9. This easyScan 2 AFM Operating Instructions manual
10. easyScan 2 Software Reference manual
11. easyScan 2 Installation CD: Contains software, calibration files, and PDF files of all manuals
12. AFM Tool set (option). The contents of the AFM Tool set are described in the next section.
13. AFM Extended Sample Kit (option, not shown) with set of 10 samples and description of experiments.
14. AFM Sample Stage (option)
15. Micrometre Translation Stage (option)
16. User's Guide; Translation Stage, Model: 9064 (with Micrometre Translation Stage)
17. Positioning Tool Set (with Micrometre Translation Stage)
18. Break-out cable (with Signal Module: S)
19. Connector box (with Signal Module: A)
20. Signal Module cables (2x) (with Signal Module: A)
21. Scripting Interface Certificate of purchase with Activation key printed on it (with Scripting Interface)
22. Instrument Case

The package may also contain easyScan 2 STM head(s) and modules for the STM, which are described in the *STM Operating Instructions*

Contents of the Tool set

The contents of the Tool set depends on the available modules. It may contain:



Contents of the AFM Tool set

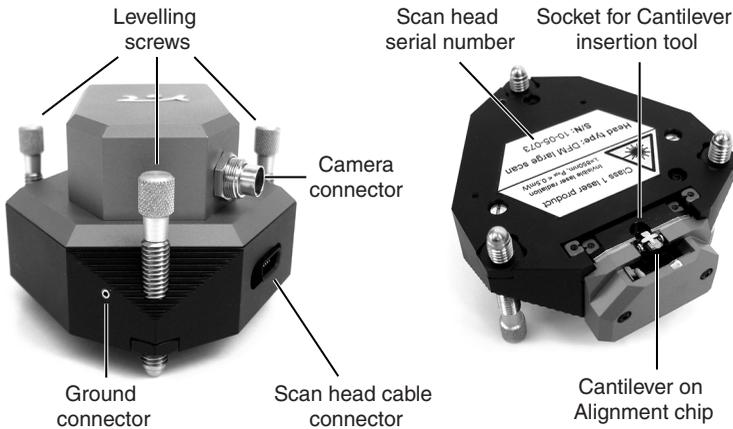
1. Ground cable
2. Protection feet
3. Cantilever tweezers: ACA 103
4. Screwdriver, 2.3mm
5. Cantilever insertion tool (usually mounted in DropStop)
6. DropStop
7. Sample holder (with AFM Sample Stage)
8. a) AFM Large Scan Sample kit (option) with Grid: 10 μ m / 100nm, CD ROM piece
b) AFM High Resolution Sample Kit (option) with Grid: 660 nm, Graphite (HOPG) sample on sample support
c) AFM Basic Sample Kit (option, no longer available) with CD-ROM Sample, Microstructure sample
9. AFM Calibration Samples Kit (option) with Calibration grid: 10 μ m/ 100nm, Calibration grid: 660nm, Flatness sample
10. Set of 10 CONTR cantilevers (option)
11. Set of 10 NCLR cantilevers (option)

12. USB dongle for the Nanosurf Report software (option)

Connectors, Indicators and Controls

Use this section to find the location of the parts of the easyScan 2 AFM that are referred to in this manual.

The Scan head



Parts of the scan head: Scan head with video camera

The Controller

Status lights

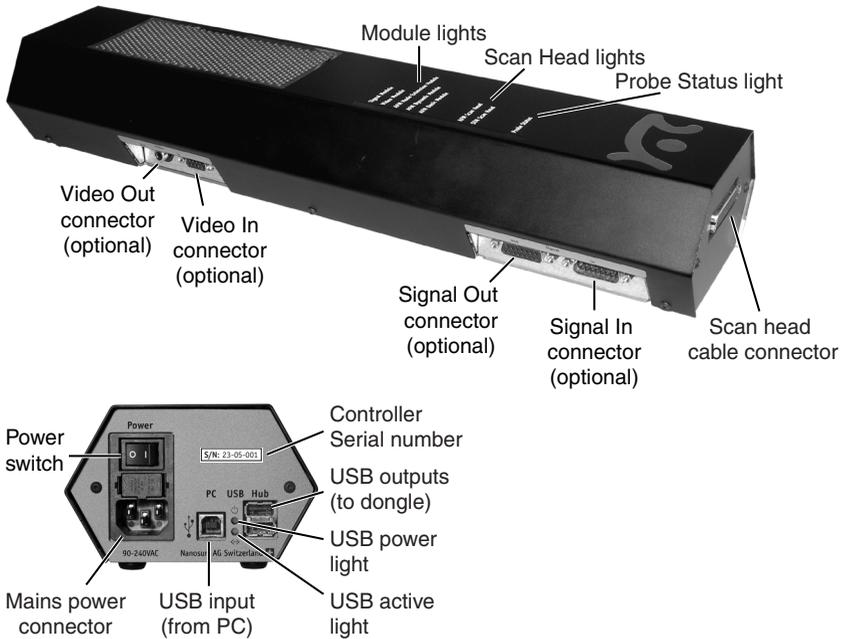
All status lights on top of the Controller will light up for one second when the power is turned on.

The Probe Status light

Indicates the status of the Z-Feedback loop. It can indicate the following statuses:

red

The scanner is in its upper limit position. This occurs when the tip-sample interaction is stronger than the set point for some time. There is danger of damaging the tip due to too high an interaction.



The easyScan 2 Controller

orange/yellow

The scanner is in its lower limit position. This occurs when the tip-sample interaction is weaker than the set point for some time. The tip is probably not in contact with the sample surface.

green

The scanner is not in a limit position, and the feedback loop can measure the sample surface.

blinking green

The feedback loop has been turned off in the software.

blinking red

There is no signal with which to do feedback: The light intensity on the photodetector of the laser beam deflection system is too low. Refer to section *Probe Status light blinks red* (p.80) for more information.

The Scan Head lights

Indicate the scan head type that is connected to the instrument. The Scan

head lights blink when no scan head can be detected, or when the Controller has not been initialised yet.

The Module lights

Indicate the modules that are built in into the Controller. The module lights blink when the Controller has not been initialised yet. During initialisation, the Module lights are turned on one after the other.

Installing the easyScan 2 AFM

The following sections describe the installation of the easyScan 2 AFM.

IMPORTANT

To make high quality measurements, the following precautions must be taken to keep equipment clean:

- Never touch the cantilever tips, the cantilevers (figure *Contents of the AFM Tool set* (p.17), 10, 11), or the open part of the Scan head (figure *Cantilever deflection detection system* (p.38)).
- Ensure that the surface to be measured is free of dust and possible residues.
- Always put the Scan head in the Scan head case during transport and storage (figure *Scan head storage*).



Scan head storage: Scan head stored in Scan head case

Installing the Hardware

WARNING



LASER RADIATION (650nm)
DO NOT STARE INTO THE BEAM
OR VIEW DIRECTLY WITH OPTICAL
INSTRUMENTS (MAGNIFIERS)
CLASS 2M LASER PRODUCT

As a consequence:

- Always close the DropStop before inspecting or mounting a cantilever or the inspecting the alignment chip, especially when using optical instruments (magnifiers) for the inspection.
- Never remove the built-in top view and side view lenses from the lens cover.
- Never remove the lens cover from the scan head.

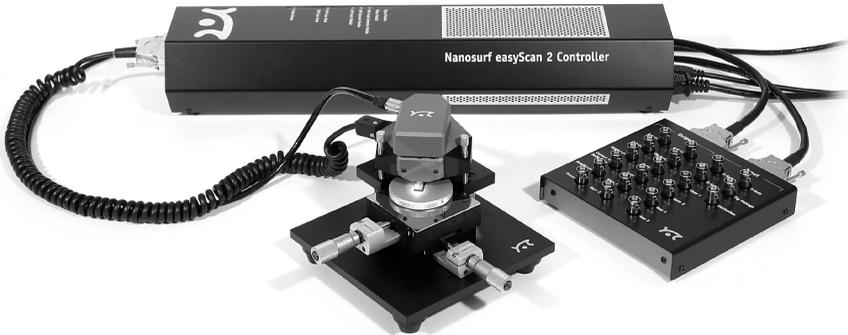
The built-in top view and side view lenses for observing the tip-sample approach have optical filters that block back-reflected laser radiation. This makes viewing the cantilever with the top and side view lenses safe.

Older Scan heads may contain lasers with 850nm wavelength infrared light, and lower optical power. These lasers have laser class 1, which does not require special protection, even when viewing the laser radiation directly with optical instruments. The wavelength and laser class are indicated next to the serial number on the scan head.

IMPORTANT

- Ascertain that the mains connection is protected against excess voltage surges.
 - Place the instrument on a stable support in a location that has a low level of building vibrations, acoustic noise, electrical fields and air currents.
-

It is recommended to cover the instrument with a box to shield it from near infrared light from artificial light sources, because this light may cause noise in the cantilever deflection detection system. If the vibration isolation of your table is insufficient for your measurement purposes, an optional active vibration isolation table is available.



easyScan 2 AFM system: System with Sample stage, Micrometre Translation Stage, AFM Video Module and Signal module: A

Installing the Basic AFM Package

- Attach the Scan head cable (figure [Components](#) (p.15), 6) to the Scan head ([Components](#), 4) using the screwdriver (figure [Contents of the AFM Tool set](#) (p.17), 4).
- Connect the Scan head cable ([Components](#), 6) to the Controller ([Components](#), 1).

The scan head cable has a helix shape in order to isolate the Scan head from vibrations of the table it is standing on. Take care that it is lying loosely on the table to ensure proper operation, and avoid stretching it.

- Connect the USB cable ([Components](#), 2) to a free USB port on your computer, but do not connect it to the easyScan 2 Controller yet. If you have inadvertently done this anyway, continue with section [Installing the Software](#) (p.26).

Installing the AFM Video Module

- Connect the Video Camera cable (*Components*, 7) to the connector on the AFM Video Camera (*Components*, 4) and the Video In connector on the Controller (figure *The easyScan 2 Controller* (p.19)).

In case of an upgrade, both the scan head and the Controller must be sent in to your local Nanosurf distributor for mounting the Video Camera on the Scan Head and installing the Video Camera electronics in the Controller. After the Controller has been returned, you should install the drivers for the AFM Video Module (section *Installing the drivers for the AFM Video Module* (p.34)).

Installing the Signal Module: S

- Connect the Break-out cable (*Components*, 18) to the Signal Out connector on the Controller (figure *The easyScan 2 Controller*).

In case of an upgrade, the Controller must be sent in to your local Nanosurf distributor for mounting the Signal Module: S electronics in the Controller.

Installing the Signal Module: A

- Connect one Signal Module cable (*Components*, 20) to the Signal Out connector on the Controller and to the Output connector on the Signal Module: A.
- Connect the other Signal Module cable to the Signal In connector on the Controller and to the Input connector on the Signal Module: A.

In case of an upgrade, the Controller must be sent in to your local Nanosurf distributor for mounting the Signal Module: A electronics in the Controller.

Turning on the Controller

- Connect the easyScan 2 Controller (*Components*, 1) to the mains using the mains cable (*Components*, 3) and turn it on.

First all status lights on top of the Controller briefly light up. Then the Scan Head lights and the lights of the detected modules will start blinking, and all other status lights turn off. The status lights remain blinking until the Controller is initialised by starting the easyScan 2 software.

Storing the Instrument

If you have to send in the instrument, transport it or if you are not using it for some time, please pack it in the shipping package or instrument case.

- Turn off the instrument as described in section *Finishing* (p.58), and remove all cables.
- Pack all components as shown in figure *Packing*.



Packing: The easyScan 2 AFM system packed in the Instrument Case

IMPORTANT

Before transport, put the Scan head in the Scan head case. Put the instrument in the original Nanosurf shipping package or instrument case.

Installing the Software

- Check that the computer on which you want to install the software fulfils the requirements listed in section *Computer requirements* (p.11).
- Disconnect the USB cable from the easyScan 2 controller.
- If you are running Windows Vista, disconnect the computer from the internet.

This way, Windows Vista can not automatically look for the most (un)suitable driver on the Internet.

- Turn on the computer and start Windows.

IMPORTANT

- Log on to your computer as an administrator.
 - Do not run any other program when you are installing the scan software.
-

- Insert the easyScan 2 Installation CD into the CD drive of the computer.

The setup program should start automatically. If this does not happen, proceed as follows:

- Open the easyScan 2 Installation CD.
- Start the program 'StartCDMenu.exe'.

Now continue the normal installation procedure.

- Click the 'Full Installation of Nanosurf easyScan 2' button.

The installation program will now start installing all components of the Nanosurf easyScan 2 AFM: The hardware drivers, the easyScan 2 software and DirectX9.

In Windows Vista, a Dialog is displayed with the title “An unidentified program wants access to your computer”.

- Click the ‘Allow’-button.
- Follow the instructions given by the setup program.

Step 1 - Installation of hardware drivers

The Nanosurf hardware needs instrument drivers for the USB hub, the USB interface and the Video Frame grabber in the video module for the easyScan 2 AFM. These drivers are installed first.

Connecting the controller to the computer

- Turn on the controller

If you do not turn on the controller, the driver for the Video module 2 will not be installed.

- Connect the USB cable to the easyScan 2 controller.

The red USB power light on the controller now lights up on controllers with normal speed USB (1.1). The red USB power light on the controller starts to blink on controllers with high speed USB (2.0).

If you have connected a high speed USB controller to a normal speed USB connector, the computer will display a message that you have connected a normal speed device to a high speed connection.

- Install the system a computer with high speed USB support if this message is displayed and you are using the video module version 2.

The image resolution of the video image will be greatly reduced if you do not use video module version 2 with a high speed USB connection.

Installing the drivers (Windows Vista)

When the controller is connected to the computer, windows automatically detects that new devices have been connected to it. On some computers, the detection process takes some time (20 seconds or more), please be patient.

If you have already installed the control software for a Nanosurf Scanning Probe Microscope on this computer, it is possible that nothing will happen, because the drivers are installed already. If this is the case, click OK in the Step 1 Dialog.

Once the computer has detected the new devices, it will display the 'Found New Hardware' Dialog.

- Click on the text 'Found New Hardware' in the Windows task bar if the 'Found New Hardware' dialog is not displayed.

The 'Found New Hardware' dialog, asks you when to install the drivers for all the new devices that if found:

- Select the entry 'Locate and install driver software (recommended)'.

The 'Windows needs your permission to continue.' Dialog is now displayed.

- Click the 'Continue'-button

The following devices can be installed, depending on the configuration of your controller:

- USB <-> serial interface
- USB Serial Port
- Unknown device (Video Module)

- Look up and carry out the installation instructions for each of these devices given in the sections below.

If something went wrong during driver installation, continue the setup normally. When the setup is finished, refer to section *Driver problems* (p.66).

- Click OK in the 'Step 1' dialog.

USB <-> serial interface

When the operating system finds the 'USB <-> serial interface', it asks what to do:

- Click the 'Next' button or the default choice in all other dialogs.

The driver 'USB High Speed Serial Converter' is now installed.

USB Serial Port

After the High Speed Serial Converter is installed, the operating system finds the 'USB Serial Port', it asks what to do:

- Click the 'Next' button or the default choice in all other dialogs.

Click the default choice in all other dialogs. The USB Serial Port is now installed.

Unknown device (Video Module)

The USB Video Adapter driver is only installed if the Controller contains a Video Module. The installation procedure depends on the version of the video module.

Video Module version 1:

When the operating system finds an 'Unknown Device', it asks what to do to:

- Select 'Browse my computer for driver software (advanced)'

A dialog called 'Browse for driver software on your computer' now opens.

- Select the path of the installation CD (usually 'D:\').
- Check the box 'Include subfolders'.

Windows Security will show the dialog box 'Windows can't verify the publisher of this driver software'.

- Select 'Install this driver software anyway'.

Windows will not install the driver, and notify that the 'USB Video Adapter' device has been successfully installed.

IMPORTANT

Repeat Step 1 for all USB ports of the PC, in order to ensure that the USB Video Adapter works when connecting the Controller to a different PC USB port.

Video Module version 2:

When the operating system finds an 'Unknown Device', it asks what to do:

- Select 'Browse my computer for driver software (advanced)'

A dialog called 'Browse for driver software on your computer' now opens.

- Select the path of the installation CD (usually 'D\').
- Check the box 'Include subfolders'.

The installation of the driver will now be finished. After all drivers have been installed, Found New Hardware may notify you that one 'Device driver software was not successfully installed'. This is not a problem, it will be remedied by the next step of the installation, step 1A. This step completes the installation of the Video Module version 2.

- Click the 'OK' button.

When the installation of the Video Module version 2 is completed, the computer must reboot. After rebooting, the drivers 'USB Compound device', 'USB 2.' A/V Converter' and 'USB EMP Audio device' will be installed.

Once the computer has rebooted:

- Start the Setup program again (by double-clicking the installation CD in windows Explorer)
- Click the 'Full Installation of Nanosurf easyScan 2' button.

The installation procedure should now continue with STEP 2. If the installation procedure does not continue, perhaps you have not waited for the message 'ready to use', or something else went wrong during the installation of the drivers for the video module.

Installing the drivers (Windows XP, 2000)

When the controller is connected to the computer, windows automatically detects that new devices have been connected to it. On some computers, the detection process takes some time (20 seconds or more), please be patient.

If you have already installed the control software for a Nanosurf Scanning Probe Microscope on this computer, it is possible that nothing will happen, because the drivers are installed already. If this is the case, click OK in the Step 1 Dialog.

Once the computer has detected the new devices, it will display the Dialog 'Found New Hardware'.

The following devices can be installed, depending on the configuration of your controller:

- Standard-USB-hub
 - USB <-> serial interface
 - USB Serial Port
 - USB Device (Video Module)
- Look up and carry out the installation instructions for each of these devices given in the sections below.

If something went wrong during driver installation, continue the setup normally. When the setup is finished, refer to section *Driver problems* (p.66).

- Click OK in the 'Step 1' dialog.

Standard-USB-hub

The operating system should first find the 'Standard-USB-hub', and install its driver. The installation order of the other drivers may vary.

USB <-> serial interface

When the operating system finds the 'USB <-> serial interface', it asks what to do:

- Select 'No not this time'
- Click 'Next'
- Select 'Install the software automatically (Recommended)'
- Click 'Next'

The message 'Installed USB <-> Serial' is not displayed

- Click 'Finish'

The driver 'USB High Speed Serial Converter' is now installed.

USB Serial Port

After the High Speed Serial Converter is installed, the operating system finds the 'USB Serial Port', it asks what to do:

- Select 'No not this time'
- Click 'Next'
- Select 'Install the software automatically (Recommended)'
- Click 'Next'

The message 'Installed USB <-> Serial' is not displayed

- Click 'Finish'

The driver 'USB Serial Port' is now installed.

USB Device (USB Video Adapter)

The USB Video Adapter driver is only installed if the Controller contains a Video Module. The installation procedure depends on the version of the video module.

Video Module version 1:

When the operating system finds the 'USB Device', it asks what to do to install the 'USB Video Adapter':

- Select 'No not this time'
- Install the software automatically (Recommended)

During installation of the video adapter under windows XP, windows may notify you that the driver is not digitally signed. If this happens:

- Click 'Continue installation'.
- Click the default choice in all other dialogs.

IMPORTANT

Repeat Step 1 for all USB ports of the PC, in order to ensure that the USB Video Adapter works when connecting the Controller to a different PC USB port.

Video Module version 2:

- Select 'No not this time'
- Click 'Next'.
- Select 'Install the software automatically (Recommended)'
- Click 'Next'.

The message 'Installed USB 2.0 A/V Converter is now displayed

- Click the 'Finish' button.

After the installation of the Drivers has finished, a step 1A may follow, that completes the installation of the Video Module version 2.

- Click the 'OK' button.

When the installation of the Video Module version 2 is completed, the computer must reboot. After rebooting, windows shows the notifications:

- Found New Hardware USB Device
- Found New Hardware USB EMP Audio Device
- Your New Hardware is now ready to use.
- Wait until the 'ready to use' message is displayed

The drivers 'USB Compound device', 'USB 2.0 A/V Converter' and 'USB EMP Audio device' are now installed.

- Start the Setup program again (by double-clicking the installation CD in windows Explorer)
- Click the 'Full Installation of Nanosurf easyScan 2' button.

The installation procedure should now continue with STEP 2. If the installation procedure does not continue, perhaps you have not waited for the message 'ready to use', or something else went wrong during the installation of the drivers for the video module.

Step 2 - Installation of the easyScan 2 software

- Click the default choice in all dialogs.

The setup program will ask for the directory in which the easyScan 2 software is to be installed.

- Install the software in the proposed directory.

IMPORTANT

The easyScan 2 Installation CD contains calibration information (.hed files) specific to your instrument, therefore you should keep (a backup copy of) the CD delivered with the instrument.

Step 3 - Installation of DirectX 9

The easyScan 2 software needs DirectX 9 or newer for correct operation. Click the default choice in all dialogs.

- After installing DirectX9, the computer may have to re-boot.

Installing the software on different computers

You can install the easyScan 2 software on a different computer than the one that controls the measurement, for example for running the microscope simulation, or for off-line data analysis. Please note:

- In order to use the Controller, the hardware drivers and DirectX9 must be installed on the computer to which it is connected.
- The controller and its drivers must be installed when installing the Nano-surf Scripting Interface.

Installing the drivers for the AFM Video Module

When the AFM Video Module is added to your Controller after you have installed the software, its drivers must be installed before it can be used:

- Disconnect the USB cable from the Controller.
- Turn on your computer and start Windows.

IMPORTANT

Make sure you have administrator privileges before software installation.

- Insert the easyScan 2 Installation CD into the CD drive of the computer.
- If the setup program has started automatically, click 'Exit'.
- Connect the USB cable to the easyScan 2 Controller.

The red USB power light on the Controller should now light up, and the PC should now automatically detect the 'USB Device', and asks what to do to install the 'USB Video Adapter'. On some computers, the detection and installation process may take some time (20 seconds or more), please be patient.

- Select 'Automatic installation'.

During installation of the video adapter under windows XP, windows may notify you that the driver is not digitally signed. If this happens:

- Click 'Continue installation'.
- Click the default choice in all other dialogs.

IMPORTANT

Connect the USB cable to all USB ports of the PC, in order to ensure that the instrument works when connecting the Controller to a different PC USB port.

Preparing for Measurement

This chapter describes actions that you perform on a day-to-day basis as a preparation for your measurements, when the instrument has already been set up according to the instructions in chapter *Installing the easyScan 2 AFM* (p.21). These steps are changing the cantilever, selecting a sample stage, and preparing the sample.

Initialising the easyScan 2 controller

- Check that the easyScan 2 controller is connected to the mains power, and the USB port of the control computer.
- Turn on the power.

First all status lights on top of the controller briefly light up. Then the Scan Head lights and the lights of the detected modules will start blinking, and all other status lights turn off.

- Start the easyScan 2 software on the control computer.

The main program window appears, and all status lights are turned off. Now a Message ‘Controller Startup in progress’ is displayed on the computer screen, and the module lights are turned on one after the other. When initialisation is completed, a Message ‘Starting System’ is shortly displayed on the computer screen and the Probe Status light, Scan Head status light of the detected scan head and modules will light up. If no scan head is detected, both scan head status lights blink.

- Determine which operating mode you wish to use.

Refer to the sections on Operating modes in this manual for the properties of the various operating modes.

To change the operating mode:

- Click  in the Navigator to open the Operating mode panel.
- Select the operating mode using the Operating mode drop-down menu.



Installing the cantilever

To maximise ease of use, the Nanosurf easyScan 2 AFM is designed so that the cantilever can be installed and removed without having to readjust the cantilever deflection detection system. This is possible because an alignment system is used that consists of an alignment chip and matching grooves in the back side of the cantilever chip. This positions the cantilever with micrometer accuracy (see figure *Cantilever, left*). Note though, that



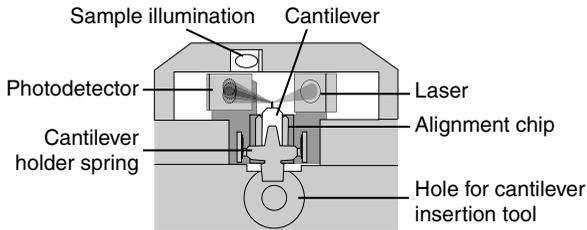
Cantilever: left: alignment system, centre: Cantilever chip viewed from the top, right cantilever 450 μm long, 50 μm wide with integrated tip.

this accuracy is only guaranteed when the cantilever and the mounting chip are absolutely clean. Installation of the cantilever should therefore still be carried out with great care because good results depend strongly on the accuracy of this process.

Selecting a cantilever

Now select the proper cantilever type for the measurement mode you wish to use. The stiffer, short NCLR cantilever is generally used for the dynamic

PREPARING FOR MEASUREMENT



Cantilever deflection detection system

operating mode; the more flexible, long CONTR cantilever is generally used for the static operating mode.

When you change to a different cantilever type:

- Select the cantilever type using the 'Mounted cantilever' drop-down menu in the Operating mode panel.

Presently, only cantilevers from the companies NanoWorld and NanoSensors can be used. The various usable types are listed in section [Compatible cantilevers](#) (p.13).

Inserting the cantilever in the Scan head

WARNING



LASER RADIATION (650nm)
DO NOT STARE INTO THE BEAM
OR VIEW DIRECTLY WITH OPTICAL
INSTRUMENTS (MAGNIFIERS)
CLASS 2M LASER PRODUCT

As a consequence:

- Always close the DropStop before inspecting or mounting a cantilever or the inspecting the alignment chip, especially when using optical instruments (magnifiers) for the inspection.
- Never remove the built-in top view and side view lenses from the lens cover.
- Never remove the lens cover from the scan head.

The built-in top view and side view lenses for observing the tip-sample approach have optical filters that block back-reflected laser radiation. This makes viewing the cantilever with the top and side view lenses safe.

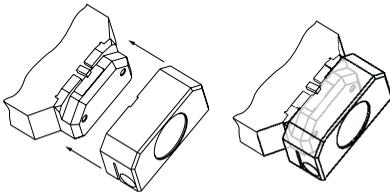
Older Scan heads may contain lasers with 850nm wavelength infrared light, and lower optical power. These lasers have laser class 1, which does not require special protection, even when viewing the laser radiation directly with optical instruments. The wavelength and laser class are indicated next to the serial number on the scan head.

CAUTION

- Nothing should ever touch the cantilever, especially the tip end!
 - The Cantilever Holder Spring (see figure [Cantilever deflection detection system](#)) is very delicate and should not be bent!
 - Always close the DropStop before handling the cantilever. Otherwise, the cantilever may fall into the scan head. This may cause malfunction of the microscope, particularly the scanner.
 - If a cantilever has dropped into the scan head, and the microscope is malfunctioning, contact your local support. Never open the scan head, because this is likely to cause damage to the scanner and the laser beam deflection detection system.
-

To insert the cantilever:

- Remove the Cantilever Insertion tool from the DropStop
- Turn the scan-head upside-down.
- Close the DropStop (figure [Closing the DropStop](#)).

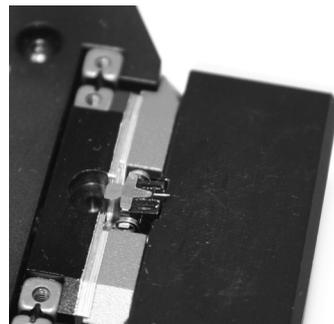
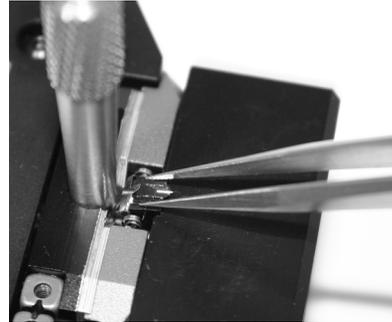
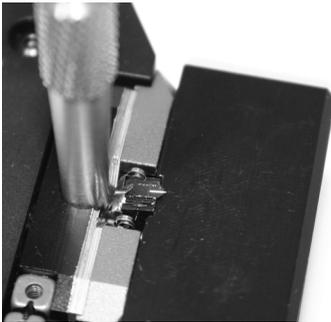


Closing the DropStop

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easyScan 2 controller. The laser beam is now blocked by the DropStop. As a consequence, the Probe Status light on the easyScan 2 controller will now blink red.

- Place the cantilever insertion tool (figure *Contents of the AFM Tool set* (p.17), 5) into the hole behind the alignment chip (figure *Mounting the cantilever, top left*). The Cantilever Holder Spring opens.



Mounting the cantilever: top left: Inserting the cantilever insertion tool; top right: Inserting/Removing the cantilever; bottom right: Correctly inserted cantilever

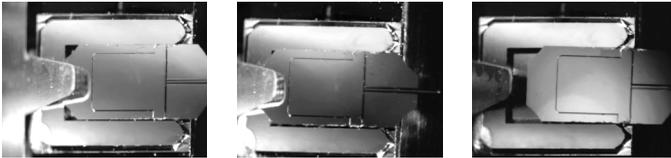
- Use the Cantilever tweezers to remove the old cantilever from the instrument (figure *Mounting the cantilever, top right*).

It is recommended to always store the Scan head with a cantilever installed.

- Take the new cantilever out of its box. The cantilever is now oriented face up.

- Let the cantilever carefully fit into the alignment chip in the Scan head (figure *Mounting the cantilever, top right*).
- Verify that the cantilever does not move with respect to the alignment chip when lightly tapping it with the tweezers.

If the cantilever does move, it is probably not inserted correctly. Refer to figure *Cantilever Alignment* for the correct alignment and examples of incorrect alignment.



Cantilever Alignment: left: Correct, the mirrored environment light shows a pattern that is continuous on the cantilever and the alignment chip; centre, right: Incorrect, the mirrored environment light shows a different pattern on the cantilever than on the alignment chip.

- Gently pull the cantilever insertion tool out of the hole; the cantilever holder spring closes and holds the cantilever chip tightly in position (figure *Mounting the cantilever, bottom right*).
- Remove the DropStop.

easyScan 2 controller The laser beam is now unblocked, and the Probe Status light on the easyScan 2 controller should now stop blinking red. If this is not the case refer to Chapter *Problems and Solutions* (p.77).

Installing the sample

Preparing the Sample

The easyScan 2 AFM can be used to examine any material with a surface roughness that does not exceed the height range of the scanning tip. Nevertheless the choice and preparation of the surface can influence the surface-tip interaction. Examples of influencing factors are excess moisture, dust, grease etc. Because of this some of the samples need special preparation to clean their surface. Generally, clean as little as possible.

If the surface is dusty, try to measure on a clean area between the dust. It is possible to blow coarse particles away with dry, oil free air, but small particles generally stick so well to the surface that they can not be removed. Note that bottled pressurised air is generally dry, but pressurised air from an in-house supply is generally not. In this case an oil filter should be installed. Blowing dust away by breath is not advisable, because it is not dry.

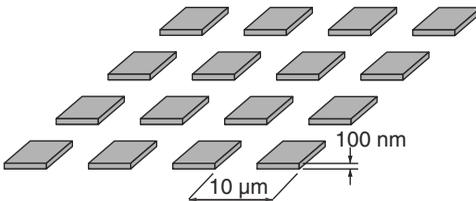
When the surface is contaminated with grease, oil or something else, the surface should be cleaned with a solvent. Suitable solvents are distilled or demineralised water, alcohol or acetone, depending on the contaminant. The solvent should be very pure, in order to prevent the collection of impurities on the surface when the solvent evaporates. The sample should be cleaned several times to remove dissolved and redeposited contaminants if it is very contaminated. Delicate samples can be cleaned in an ultrasound bath.

Nanosurf Samples

Nanosurf delivers various optional samples that are usually packed in the AFM Tool kit. These samples are described here. The description of the AFM Extended Sample kit is included in the Extended Sample kit.

All samples should be kept in their box. Then it should be unnecessary to clean them. Cleaning is not advisable, because the grids is rather delicate.

Grid: 10 μm / 100 nm



Structure of Grid: 10 μm / 100 nm

The Grid: 10 μm /100 nm can be used for testing the xy-calibration of the 70 μm and 100 μm scanners and for testing z-calibration. It is manufactured using a standard silicon process that produces silicon oxide squares on

a silicon substrate. It has a period of 10 μm and a square height of approximately 100 nm.

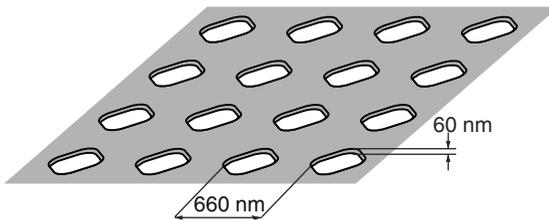
size: 5 mm x 5 mm

material: silicon oxide on silicon

structure: square array of square hills of silicon oxide hills on silicon

Grid period: 10 μm , approx. height: 100 nm, calibrated values of period and height (with 3 % accuracy) given on package. Certified Calibration grids are available as an option.

Grid: 660nm



Structure of Grid: 660nm (version with holes)

The Grid: 660 nm can be used for testing the xy-calibration of the 10 μm scanner. Depending on its make, it consists either of

- silicon oxide hills on a silicon substrate with a period of 660 nm and an unspecified height. The approximated height is 149 nm,
- holes in a silicon oxide layer with a period of 660 nm and an unspecified depth. At the time of writing, the approximated depth is 60 nm.

size: 5 mm x 5 mm

material: silicon oxide on silicon

structure: square array of holes or hills in the silicon oxide layer

period: 660 nm, calibrated value of period (with 3 % accuracy) given on package. Certified Calibration grids are available as an option.

Flatness Sample

The Flatness sample is a polished silicon sample. It can be used for testing the Flatness of the scanned plane.

PREPARING FOR MEASUREMENT

size: 5 mm x 5 mm

material: silicon

thickness: appr. 320 μm

CD-ROM piece

Sample for demonstrating the AFM imaging. The CD sample is a piece from a CD, without any coating applied to it.

material: Polycarbonate

structure: 100 nm deep pits, arranged in tracks spaces 1.6 μm apart.

Microstructure

Sample for demonstrating the AFM imaging (no longer available). The microstructure is approximately the negative of the Grid: 10 μm / 100nm. It consists of holes in a silicon oxide layer with an unspecified period and depth. The approximate period is 10 μm , the approximate depth is 100 nm.

Graphite (HOPG) on sample support

The sample can be used for both STM and AFM measurements. In high resolution AFM measurements the atomic steps on the graphite surface can be seen. Conductivity variations can be observed in spreading resistance mode.

size: approx. 5 mm x 5 mm

material: Highly Oriented Pyrolytic Graphite (HOPG)

Sample support: Magnetic Steel disc, galvanically coated with Nickel.

Stand-alone measurements

You can either use the instrument with the sample stage, or as a stand-alone instrument. The sample stage offers vibration isolation, and a stable scan head mount. Therefore, operate the instrument as a stand-alone only when the sample is too large for the sample stage. For stand-alone measurements, put the Scan head directly on top of the sample. Protection feet for under the three alignment screws are provided to protect delicate samples from being scratched (figure *Contents of the AFM Tool set* (p.17), 2).

The sample stage

The sample stage (figure [Components](#) (p.15), 14) offers vibration isolation and stable positioning and can be used to comfortably position the sample. An optional micrometre translation stage for X-Y positioning can be mounted on the sample stage. You can either put the sample directly on the sample stage, or mount it on the sample holder (figure [Contents of the AFM Tool set](#) (p.17), 7).



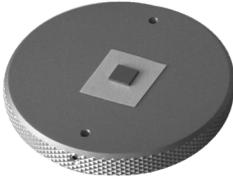
easyScan 2 AFM Scan head on the Sample Stage

Mounting a sample onto the sample holder

The simplest way to mount the sample onto the sample holder:

- Put a double-sided adhesive tape on backside of a Post-it[®] note, so that it is on the opposite side of the sticky side.
- Cut off the all parts of the note that do not have adhesive tape on it.
- Fix side of the note with the double-sided adhesive tape to the sample holder.
- Put the sample on the sticky side of the Post-it[®] note, and slightly press on it.

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Sample mounted onto the sample holder

It is recommended to always connect the sample holder to the ground connector on the scan head using the ground cable (figure [Contents of the AFM Tool set](#) (p.17), 1).

CAUTION

Avoid touching the cantilever when placing the sample holder under the Scan head. If the sample touches the tip it will be damaged.

A First Measurement

In this chapter, step by step instructions are given as to how to operate the microscope and make a simple measurement. More detailed explanations of the software and the system are given in further chapters of this manual.

Running the microscope simulation

You can start the easyScan 2 software without having the microscope connected to your computer in order to explore the easyScan 2 system (measurements and software) without danger of damaging the instrument or the cantilever. In the simulation mode, most functions of the real microscope are emulated. The sample is replaced by a mathematical description of a surface.

When you start the easyScan 2 software when no microscope is connected to your PC, the following dialog appears:



- Click 'OK'.

The status bar will now display the text 'Simulation'.

You can also switch to the simulation mode with the microscope connected:

- Select the menu entry 'Options>Simulate Microscope'.

A check will now be displayed in front of the menu entry.

To exit the Microscope simulation mode:

- Select the menu entry 'Options>Simulate Microscope' again.

The check in front of the menu entry is now removed, and the status bar will now display the text 'Online'.

Preparing the instrument

IMPORTANT

- Never touch the cantilever or the surface of the sample! Good results rely heavily on a correct treatment of the tip and the sample.
 - Avoid exposing the system to direct light while measuring. This could influence the beam deflection detector and reduce the quality of the measurement.
-

Prepare the instrument as follows (see chapter *Preparing for Measurement* (p.36) for more detailed instructions):

- If you have the AFM Dynamic Module, install an NCLR type cantilever, otherwise install an CONTR type cantilever.
- Install one of the samples from the Nanosurf AFM Basic sample kit or Calibration sample kit. Preferably install the 10 μm Calibration grid when using a 70 μm or 110 μm scan head and the 660 nm Calibration grid when using a 10 μm scan head.

The measurement examples shown here were made with the 10 μm Calibration grid.

To make sure that the configuration is correct, do the following:

- Open the User interface dialog via the menu 'Options/Config User Interface...'.
 - Select the 'Easy level' user interface mode.
- Open the menu item 'File>Parameters>Load...', and load the file 'Default_EZ2-AFM.par' from the directory with default easyScan 2 configurations. Usually this is 'C:\Program Files\Nanosurf\Nansurf easyScan 2 software\Config'.

Entering values in the control panels

To change a parameter in any panel, use one of the following methods:

- Activate the parameter by clicking it with the mouse pointer, or by select-

ing it with the Tab key.

- The value of an activated parameter can be increased and decreased using the up and down arrow keys on the keyboard. The new value is automatically used after one second.
- The value of a numerical parameter can also be increased and decreased by clicking the arrow buttons  with the mouse pointer. The new value is automatically used after one second.
- The value of an active numerical parameter can also be entered using the keyboard.

The entered value is used on pressing the ‘Enter’ or ‘Return’ key, or by activating another input.

The entered value is discarded on pressing the ‘Esc’ key.

Type the corresponding character to change the unit prefix:

<u>prefix</u>	<u>keyboard key</u>	<u>prefix</u>	<u>keyboard key</u>
femto	f	no prefix	space bar
pico	p	kilo	k
nano	n	mega	shift - M
micro	u	giga	shift - G
milli	m	tera	shift - T

Unit prefixes with corresponding character

For example, if the basic unit is Volts, type ‘m’ to change to millivolts, type the space bar for volts, type ‘u’ for microvolts.

- The selection of a drop-down menu (e.g.: ) can be changed using the mouse or the up and down arrow keys on the keyboard.

Sometimes the program will change an entered parameter value to a slightly different value. This happens when the desired value is outside the range that the easyScan 2 Controller can handle, for example due to the resolution limits or timing limits. The desired value is automatically changed to the nearest possible value.

Approaching the sample

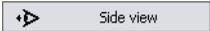
To start measuring, the tip must come within a fraction of a nanometer of the sample without touching it with too much force. To achieve this, a very careful and sensitive approach of the cantilever is required. This delicate operation is carried out in three steps: Manual coarse approach, manual approach using the approach stage, and the automatic final approach. The colour of the probe status light on the controller shows the status of the approach:

orange	Normal state during approach, the Z-scanner is fully extended toward the sample.
red	The approach has gone too far, the tip was driven into the sample, and the Z-scanner is fully retracted from the sample. In this case, the tip is probably damaged, so you will have to start over again with installing a new tip.
green	The approach is finished, the Z-scanner is within the measuring range.

The approach is operated using the Positioning window. To open this window:

- Click the Positioning icon  in the Navigator.

Use the side view of the cantilever to judge the distance between tip and the sample surface. To use the side view:

- If the AFM Video Module is installed, click  in the Video panel of the Positioning window.
- If you do not have the Video Module, use the side view lens to observe the sample instead.

Even if you do not have the Video Module, you can use the Top and Side view switches to quickly change the illumination to a predetermined level.

The side view should look like figure *Side view of the cantilever after manual coarse approach*. You can use the cantilever as a ruler to judge distances in the views of the integrated optics.



Side view of the cantilever after manual coarse approach

Manual Coarse approach

In this step, the sample surface is brought within the range of the fine approach stage.

- Use the three levelling screws (figure *Parts of the scan head* (p.18)) to lower the Scan head so that the cantilever is within 1-2 mm of the sample. Take care that the Scan head remains levelled parallel to the sample surface by turning all screws approximately the same amount.

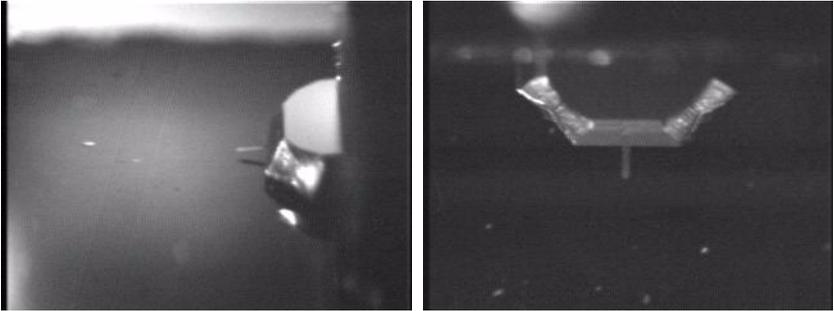
When the sample is reflective, the mirror image of the cantilever should now be visible (figure *Side view of the cantilever after manual coarse approach*). When the sample is not reflective, the shadow of the cantilever may be visible. If neither a mirror image nor a shadow are visible, change the light until it is visible, for example by adding a light source, or by shading the light from outside or from bright surfaces in the room.

Manual approach using the approach stage

In this step, the tip is brought as close to the sample surface as possible, without running a risk of touching it. The closer the tip is, the less time the automatic final approach takes.

- Observe the distance between tip and sample in the side view of the inte-

grated optics. The tip should not come closer to the sample than a few times the cantilever width. (figure *View of the cantilever after manual approach, left*).



View of the cantilever after manual approach: left: side view, right: top view

- Whilst observing the tip sample distance, click and hold  until the tip is close enough to the sample.

The sample should now be in focus. Now use the top view image to find a suitable location to measure on. In the top view, the sample is seen from a direction perpendicular to its surface (figure *View of the cantilever after manual approach, right*). To use the top view:

- If the Video Module is installed, click  in the Video panel.
- If you do not have the Video Module, use the top view lens to observe the sample instead.

If necessary, move the sample holder to find a suitable location that is free of dust particles.

Automatic final approach

In the last step, the tip approaches the sample until the set point is reached. First check that you are using the right operating mode and cantilever:

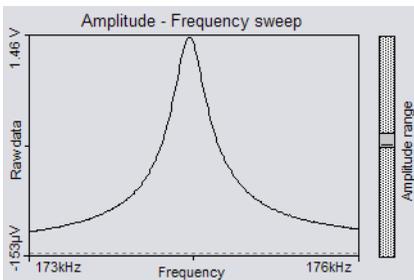
- Click  in the navigator to open the Operating Mode panel.

- If you are operating in Static Force mode, select a CONTR type cantilever.

In dynamic mode, the instrument will automatically determine the vibration frequency used in the dynamic mode. To do this, it uses a measurement of the cantilever vibration amplitude as a function of excitation frequency. This measurement is not displayed when using the default settings. Nevertheless, it is instructive to see this measurement at least once. To display the measurement:

- Open the User interface dialog via the menu ‘Options/Config User Interface...’.
- Select the ‘Standard level’ user interface mode.
- Enable ‘Display sweep chart’ in the Mode Properties section of the Operating mode panel.
- Click the ‘Set’ button.

The software will now perform a coarse and fine frequency sweep, and display the results (figure *Fine frequency sweep*). For more details on the frequency search procedure see section *The Operating mode panel* (p.95).



Fine frequency sweep: Cantilever vibration amplitude as a function of frequency.

Now restore the default settings:

- Disable ‘Display sweep chart’ in the Mode Properties section of the Operating mode panel.
- Select the ‘Easy level’ user interface mode.

Now check that the set point and the feedback speed are set properly:

- Click  in the Navigator to open the Z-Controller panel.

For Dynamic Force mode:

- Set 'Set point' to 50-70%.

For Static Force mode:

- Set 'Set point' to 10-20nN.
- Set 'Loop gain' to 1000-1500.

Now you can start the approach:

- Click  in the Approach panel.

The cantilever is moved towards the sample using the approach stage, with the Z-Controller turned on. The motion continues until the Z-Controller error becomes zero. From now on the distance between sample and tip is controlled automatically by the electronics. A message 'Approach done' appears when the approach has been completed.

Starting a measurement

Now that the tip-sample interaction defined by Set point is flowing between tip and sample you can start measuring:

- Click  to open the Imaging window.

The instrument was set to automatically start measuring after the automatic approach. Two representations of the ongoing measurement are drawn in the Imaging panel. One representation is a color coded height image, called a Color map, the other is a plot of height as a function of X^* position called a Line graph. Watch the displays for a while until about a quarter of the measurement has been measured. With the current setting, the software automatically adjusts the contrast of the Color map, and height range of the Line graph to the data that have been measured.

Reminder

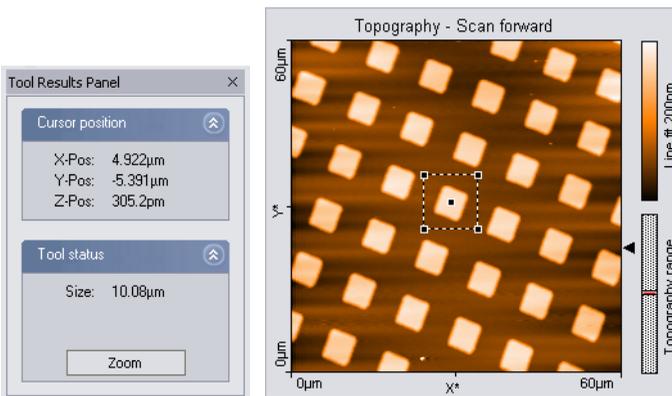
Measurements on the micrometer/nanometer scale are very sensitive. Direct light, fast movements causing air flow and temperature variations near the Scan head can influence and disturb the measurement.

When the measurement contains large disturbances, or no two scan lines are similar, stop measuring and reduce or eliminate the disturbances:

- Click and follow the instructions of the chapter *Problems and Solutions* (p.77).

Selecting a measurement area

You have prepared your measurement so that the scan line in the centre of the Line graph reproduces stably. After the measurement has been completed, the color map graph should look similar to the one shown below.



Zooming in on an overview measurement

Now zoom into an interesting part of the measurement:

- Activate the color map graph by clicking on it.
- Click in the imaging toolbar. The mouse pointer becomes pen-shaped when moving over the color map, and the Tool Results panel is

displayed.

Select an interesting region by drawing a square with the mouse pointer:

- Click on one corner of the region using the left mouse button, and keep the button pressed.
- Drag the mouse to the other corner of the region, and then release it.

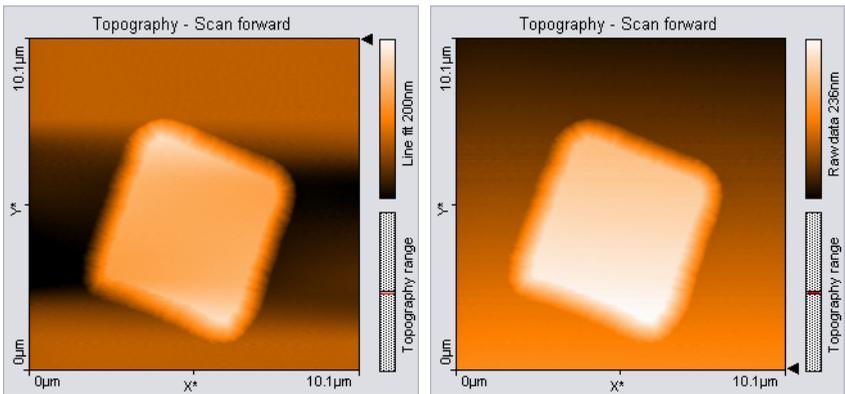
The size and the position of the square are shown in the Tool result panel.

- Release the mouse button when the square's size covers approximately one period of the grid.

- Confirm the selection by double clicking the color map graph using the left mouse button. Now the selection is enlarged to the whole display size.

You can abort the zoom function by clicking  again.

The microscope will now start measuring a single grid period. Once the measurement is completed, you should get an image such as the one in figure *Zoomed measurement, left*. The depression in the sample surface to the sides of the structure is due to data filter used. To remove it, select the data filter 'Raw Data' in the Data filter drop-down, indicated by the  icon in the Chart bar. The chart will now become similar to figure *Zoomed measurement, right*.



Zoomed measurement: left: with line subtraction, right: without line subtraction.

Storing the measurement

When you are satisfied with your image and would like to keep it, you can take a snapshot of it by clicking the  button. The behaviour of this button depends on whether a measurement is in progress or not.

When a measurement is in progress, and  is activated, a copy of the measurement is made to a measurement document after the measurement is finished.

When the measurement is not in progress, a copy is made immediately.

If you would like to take the snapshot of the measurement as it appears during the measurement without waiting to finish:

Stop the scanning by clicking .

- Generate a snapshot by clicking .

If you want to save the measurement document to your hard disk drive, for example for loading it to Nanosurf Report:

- Activate the measurement document by clicking in its window, or by selecting it in the 'Windows' menu.
- Select the menu 'File>Save as...'. Select the folder and name where you would like to store the measurement.

The stored measurements can now be loaded with the easyScan 2 AFM software or the optional Nanosurf Report and Nanosurf Analysis software packages for later viewing, analysis and printing. For more information on starting the Report software, see section [Creating a report](#) (p.153).

Creating a report

The optional Nanosurf Report software can be used for evaluating the measurement, and creating visually appealing reports. Here, we will just start the software and create a basic report. For an in depth introduction to the Nanosurf Report software, refer to the Introduction section of the Nanosurf Report online help.

To start Report:

- Click  in the Navigator.

The Report software will now start, open the currently selected measurement in the report software, and evaluate it with the default template.

IMPORTANT

After a fresh installation of the Report software, the Report software has to have run at least one time before you can automatically start it from the easyScan 2 software. To run the Report software for the first time, select it from the Microsoft Windows 'Start' menu.

Finishing

Once you are done measuring:

- Click  to stop measuring.
- Open the positioning window.
- Click .
- Retract the cantilever to a safe distance from the sample by clicking  until the tip-sample distance is at least as large as shown in figure *View of the cantilever after manual approach* (p.52).

Turning off the instrument

- Verify that you have saved all measurements that you would like to keep.
- Exit the easyScan 2 software after having stored all desired measurement documents. If you exit the program whilst having some unsaved measurements, you will be asked to save them now.
- Turn off the power switch.
- Store the Scan head in the Scan head case.

IMPORTANT

Always store the scan head with an (old) cantilever installed. This will prevent dust from gathering on the alignment chip, and protect the alignment chip against damage.

Improving measurement quality

Removing interfering signals

Interfering signals can be recognised because they have a fixed frequency, usually a multiple of the local mains frequency (50 or 60 Hz) throughout the image. Thus, they are manifested by straight lines that run throughout the image.

Possible interference sources are:

- Mechanical vibrations from machines or heavy transformers in the environment (e.g. pumps).
- Infrared light sources (light bulbs, sample illumination in an inverted microscope).
- Electrical interference (in the electronics, or in electrical forces in the tip-sample interaction).

Mechanical vibrations

Measure the frequency of the vibrations to find out if the interference is due to mechanical vibrations. These vibrations have a frequency that is (a multiple of) the rotation frequency of the source. This frequency is usually not a multiple of the local mains frequency, and may change slightly over time. Try the following to find out if the interfering signal is due to mechanical vibrations:

- If possible, turn off all rotating machines (i.e. pumps) in the room.
- Change the vibration isolation by putting the Scan head directly on the table, instead of on the Sample stage.

To reduce the influence of these vibrations, either improve the isolation of these machines, or improve the isolation of the instrument by using a vibration isolation table (e.g. the optional TS-150 active vibration isolation table).

Electrical interference

Electrical interference may be caused by interference in the electronics, or by electrostatic forces acting between the tip and the sample. Try the following in order to reduce the influence of electrical interference:

- Connect the instrument to the mains power supply using sockets with line filters and surge protection.
- Connect the sample, or when it is not conducting, the sample support to the sample holder to the ground connector on the scan head using the ground cable (figure *Contents of the AFM Tool set* (p.17), 1).
- Remove interfering electromagnetic field sources, such cathode ray tube displays, loudspeakers, ...

Infrared light sources

Infrared light sources can influence the deflection detection system. This problem is especially severe when measuring in the Static Force mode. Try the following in order to reduce the influence of infrared light sources:

- Turn off the light.
- Shield the instrument from external light sources.
- When using the instrument with an inverted microscope, use filters that filter out infrared light.

Judging measurement quality

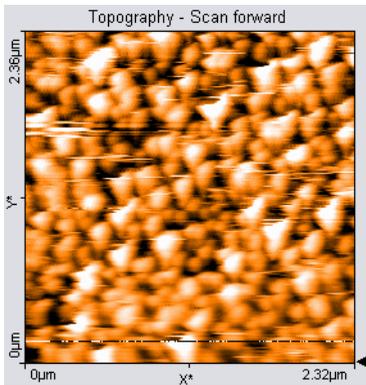
When all other improvements have been made, the measurement quality depends mainly on the quality of the tip. A good tip quality is necessary for high quality images of high resolution.

- When the image quality deteriorates dramatically during a previously good measurement, the tip has most probably picked up some particles (section *Image quality suddenly deteriorates* (p.81)).

In the following cases the cantilever has to be replaced in order to re-establish high image quality:

- images in the color map charts consist of uncorrelated lines only.
- images appear blurred.
- First follow the suggestions in section *Image quality suddenly deteriorates* (p.81). If these do not help, the cantilever should be changed.

If all peaks in the image have the same, usually triangular shape, the tip is no longer sharp and has to be replaced. The measured structure is called a tip artefact.

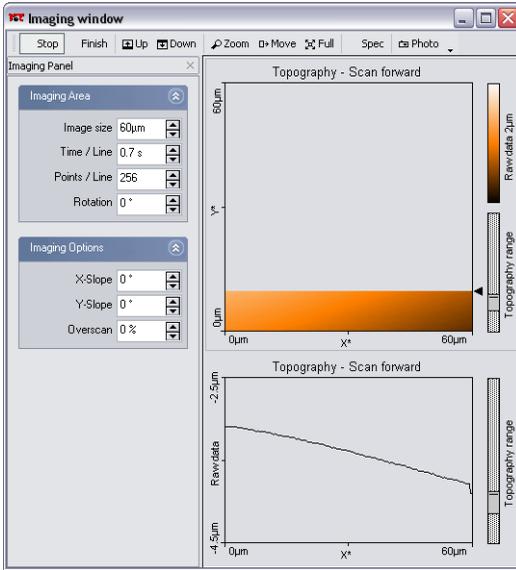


Measurement containing tip artefacts

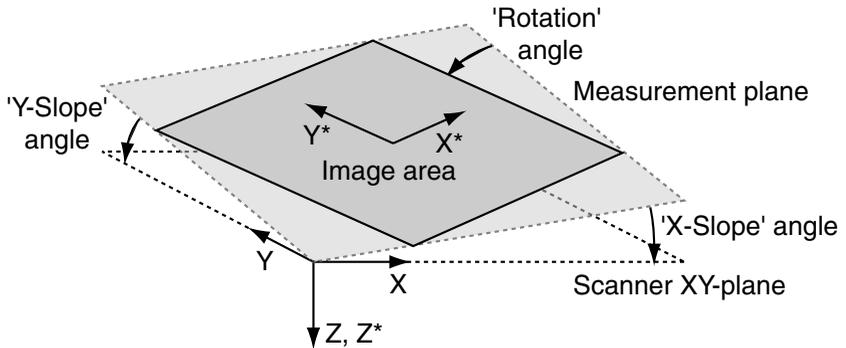
Adjusting the measurement plane

Ideally, the sample surface and the XY-plane of the scanner are all parallel. But in most cases, the sample plane is tilted with respect to the XY-plane of the scanner. In this case, the sample cross section in the X^* measurement direction has a certain slope. The Line graph chart in figure *Maladjusted slope* is an example. This slope depends on the direction of the X^* direction and therefore on the rotation of the measurement, as shown in figure *Slope*. This slope is undesirable for several reasons:

- It makes it difficult to see small details on the sample surface when the Average, Plane fit or higher order filters can not be used.
- The Z-Controller functions less accurately, because it has to compensate for the sample slope.



Maladjusted slope: measurement with improperly set X-slope*

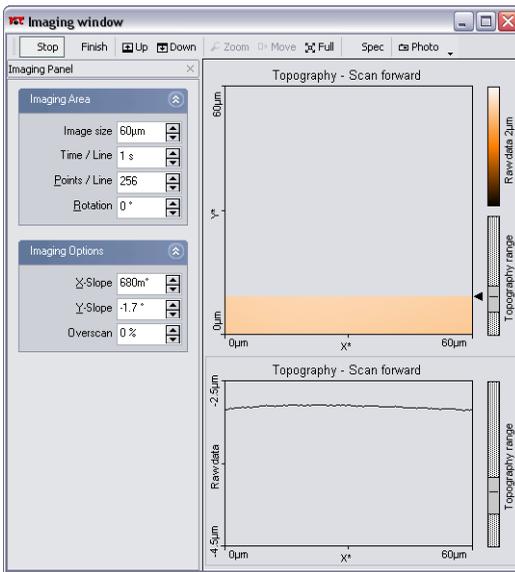


Slope: Sample's and measurement orientation before slope adjustment

Ideally, the XY-plane of the scanner has already been correctly aligned with the sample plane using the three Levelling screws on the Scan head. However, this alignment can not be performed once the automatic approach has been done, because this will damage the tip. During measurement, the measurement plane should therefore be adjusted electronically using the parameters 'X-Slope' and 'Y-Slope'.

To find the correct values, use the following procedure:

- Open the User interface dialog via the menu 'Options/Config user interface, and select one of these modes. The slope correction is only available with the Standard level and the Advanced level user interface mode.
- Measure the slope in the Line graph using the angle tool (section *Measure Angle* (p.143)). Use a single click to measure the angle relative to the X*-Axis.
- Alter the value of 'X-Slope' in the Imaging options of the Imaging panel until the x-axis of the scan line lies parallel to the X-axis of the sample.



Displays after adjusting the slopes

- Set Rotation to 90° to scan along the y-direction of the scanner.
- If the scan line is not horizontal, alter the value for 'Y-slope' until the y-axis of the scan lies parallel to the y-axis of the sample.
- Reset 'Rotation' to 0°. The Line graph shows the X-slope again.

Measurement modes

This chapter instructs you on how to use the Dynamic Force, Static Force, Phase contrast, the Force Modulation, and Spreading Resistance modes. If you are unfamiliar with the Atomic Force Microscopy Technique, it is recommended to first read the chapter *AFM Theory* (p.83).

The amount of available modes depends on the Scan head and the available modules built into the easyScan 2 controller. The modules required to be able to use a certain operating mode are listed in table *Operating modes and required modules*. The modes can be divided into the static operating modes that control the Z-position control using the Cantilever deflection, the dynamic operating modes that control the Z-position using the vibration amplitude.

Operating mode	Required modules
Static force	AFM Basic
Dynamic force	AFM Basic, AFM Dynamic
Phase contrast	AFM Basic, AFM Dynamic, AFM Mode Extension
Force Modulation	AFM Basic, AFM Dynamic, AFM Mode Extension
Spreading Resistance	AFM Basic, AFM Dynamic, AFM Mode Extension

Operating modes and required modules

Static Force

In the Static Force mode, the ‘static’ deflection of the cantilever is used as the error signal for the Z-Controller. The Set point in Newton is calculated by multiplying the deflection with the spring constant of the selected cantilever. In order to minimize tip/sample wear, the force set point should be made as small as possible. In some cases, even a negative set point (i.e. an adhesive force) may work, but when the tip momentarily loses contact with the sample due to some disturbance, the Z-Controller will always fully retract the cantilever from the sample. Moreover, working in this range may cause image artefacts due to instabilities in the tip-sample contact.

Both the Force Modulation mode and the Spreading Resistance mode are an extension of the Static Force mode.

The procedure for a first Static Force mode measurement is basically the procedure described for the Dynamic Force mode in chapter *A First Measurement* (p.47). The main differences are:

- Use a suitable cantilever type (usually CONTR), and select this type in the Operating Mode panel.
- Select the Static Force mode in the Operating Mode panel.
- Set the force Set point in the Z-Controller panel.

For a more detailed description of the parameters that you can set, refer to section *The Operating mode panel* (p.95).

Dynamic Force

In the Dynamic Force mode, changes in the dynamic behaviour of the cantilever are detected by measuring changes in its vibration amplitude when it is excited with a sinusoidal signal with a frequency close to the cantilever's free resonance frequency. When the cantilever tip comes close to the sample surface, this vibration amplitude will generally go down. Thus the set point is the percentage of the vibration amplitude when the cantilever was far away from the surface. A small percentage means a big reduction, a large percentage means a small reduction. To minimize tip/sample wear, the set point should be made as large as possible. However, when the Set-point becomes too large, the Z-Controller may not be able to optimally follow the sample surface, and artifacts may occur due to instabilities in the cantilever vibration.

The procedure for a first Dynamic Force mode measurement is described for the Dynamic Force mode in chapter *A First Measurement* (p.47). For more information on how the vibration amplitude and frequency are set, refer to section *The Operating mode panel* (p.95).

Phase Contrast

The Phase Contrast mode is an extension of the Dynamic Force mode. In addition to the vibration amplitude, the phase shift between the cantilever vibration and a reference signal is measured. This phase shift changes when the resonance characteristic of the cantilever changes due to changes in the tip-sample interaction. Thus, the Phase contrast mode can be used to produce material contrast when there is a significant difference in the tip sample interaction of these materials. This section gives a brief description of how to operate the easyScan 2 AFM in phase contrast mode. For a more detailed description of the parameters that you can set, refer to section *The Operating mode panel* (p.95).

The phase contrast mode can also be used to do Magnetic and Electrostatic Force Microscopy. For more information on how to do Magnetic Force Microscopy, refer to technical note *TN00031 Magnetic Force Microscopy*, which can be downloaded from the support section of the Nanosurf web site at www.nanosurf.com.

Proceed as follows to operate the easyScan 2 AFM in the Phase Contrast mode:

For Phase contrast mode, you can use the same cantilevers that you use for Dynamic force mode.

- Select the Phase Contrast mode in the Operating Mode panel.

To display the measurement results:

- Create a new chart in the Imaging window by clicking  in the Chart bar.
- If necessary, increase the size of the window to make space for the new chart.
- Select the 'Color map' chart type by .
- Select the 'Phase' signal by .

The reference phase is usually set automatically after the approach so that the average phase shift lies in the centre of the measurement range. To automatically readjust the phase shift:

- Ensure that you have selected the ‘Standard level’ or ‘Advanced level’ user interface mode in the User Interface dialog.
 - Click ‘Reference phase’: in the Operating mode panel.
- If you do not want to automatically set the reference phase:
- In the Operating mode panel, deactivate Reference phase: ‘Auto set’.
 - Enter the reference phase using the ‘Reference phase’ input.

Phase measurement

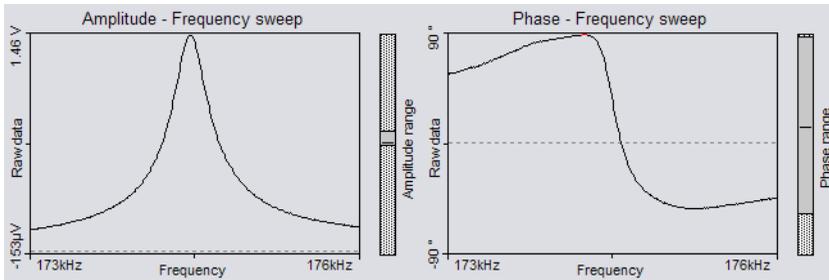
In Phase contrast mode, the phase of the measured cantilever vibration is compared to the phase of a reference sine wave. The phase comparison is performed by multiplying the measured vibration signal with the reference. The measured phase, $\phi_{measured}$, is the output of this multiplier, is related to the actual phase shift between the measured vibration and the excitation sine wave, ϕ_{actual} , as:

$$\phi_{measured} = 90^\circ \sin(\phi_{actual} - \phi_{reference}) ,$$

with $\phi_{reference}$ a reference phase that can be set by the user. This has two important consequences:

- The measured phase shift lies between -90° and $+90^\circ$, phase shifts outside this range are folded back into the -90° to $+90^\circ$ range. The measurement does not distinguish between phase ϕ and phase $\phi + 180^\circ$.
- The phase shift measurement becomes less sensitive when the phase approaches $+90^\circ$ and -90° .

Note that the phase of the cantilever vibration changes by 180° symmetrically around its resonance frequency. This phase shift only fits into the -90° to $+90^\circ$ range when the reference phase is set so that it is zero at the resonance frequency. However, the operating frequency is generally set to be different than the resonance frequency. Then, the reference phase is automatically set so that the phase shift is zero at the operating frequency. Thus, part of the frequency spectrum of the phase shift will be folded back into the -90° to $+90^\circ$ range (figure *Folded back*).



Folded back: Frequency spectrum with phase shift folded back over the +90° limit

Force Modulation

The Force Modulation mode is an extension of the Static force mode. The static force acting on the cantilever is still used to produce a topography image of the sample. Simultaneously, the cantilever is excited and the resulting vibration amplitude measured. The vibration amplitude depends on the drive amplitude, the stiffness of the cantilever and, most importantly, the stiffness of the tip-sample contact. Thus, the force modulation mode can be used to produce material contrast when there is a significant difference in the stiffness of the tip-sample contact of these materials. This section gives a brief description of how to operate the easyScan 2 AFM in force modulation mode. For a more detailed description of the parameters that you can set, refer to section *The Operating mode panel* (p.95).

Proceed as follows to operate the easyScan 2 AFM in the Force Modulation mode:

- Select a cantilever that has a spring constant that is suitable for the sample stiffness that you expect.

Good results were obtained with LFMR-type cantilevers. The FMR type cantilever, which is explicitly sold for Force Modulation mode measurements, cannot be used due to its insufficient width.

- Install the cantilever as described in section *Installing the cantilever* (p.37).
- Select the Force Modulation mode in the Operating mode panel.
- If necessary, verify the force Set point in the Z-Controller panel.

- In the Operating mode panel, click  to measure the frequency characteristic of the cantilever.
- Note the cantilever resonance frequency from the sweep chart and set 'Excitation frequency' to this value.
- Set 'Excitation amplitude' to the desired modulation amplitude.
- Increase the excitation amplitude when no Force Modulation signal can be measured.

To display the measurement results:

- Click  in the Chart bar to create a new chart in the Imaging window.
- If necessary, increase the size of the window to make space for the new chart.
- Select the 'Color map' chart type by .
- Select the 'Amplitude' signal by .

Spreading Resistance

The Spreading Resistance mode is an extension of the static force mode. The static force acting on the cantilever is used to produce a topography image of the sample. Simultaneously, changes in the spreading resistance from the cantilever tip to a ground contact on a sample can be imaged by measuring changes in tip current whilst a fixed voltage is applied to the tip. This section gives a brief description of how to operate the easyScan 2 AFM in Spreading Resistance mode. For a more detailed description of the parameters that you can set, refer to section *The Operating mode panel* (p.95).

Proceed as follows to operate the easyScan 2 AFM in the Spreading Resistance mode:

- Electrically connect the sample to the Ground connector on the easyScan 2 AFM Scan head (figure *Parts of the scan head* (p.18)) via a 100kOhm resistor, in order to prevent damage to the tip due to an excessive current.

For best results, the sample should be electrically isolated except for the connection mentioned above.

- Select a cantilever:

CDT-NCLR should be used for samples where a high force is needed to penetrate a surface oxide layer.

CONT-PtIr cantilevers can be used on delicate samples. The applied voltage should be small, because high currents may cause the conducting layer on the tip to evaporate. Also, applied forces should be very small to prevent damage to the conducting layer.

NCL-PtIr cantilevers could be used in combination with non-contact topography measurements, but damage to the tip is likely.

IMPORTANT

- Standard CONTR cantilevers can not be used due to the surface oxide on the tip, and the semiconducting contact between the tip and the sample.
- EFM cantilevers cannot be used for static force mode measurements, due to their insufficient width.

-
- Install the cantilever as described in section *Installing the cantilever* (p.37).
 - Select the Spreading resistance mode in the Operating mode panel.
 - Open the Z-Controller panel.
 - Verify the force Set point.
 - Set the Tip voltage in the section Tip Properties.

To display the measurement results:

- Create a new chart in the Imaging window by clicking  in the Chart bar.
- If necessary, increase the size of the window to make space for the new chart.
- Select the 'Color map' chart type by .
- Select the 'Tip current' signal by .

The Signal Modules

The Signal Modules consist of both electronics modules that are built into the easyScan 2 controller and a break-out Connector that is externally attached to the controller. The Signal Modules can be used for monitoring the signals (Signal Module: S) and adding functionality to the easyScan 2 system (Signal Module: A). The Signal Module: A includes all the monitoring functions of the Signal Module: S.

For information on installing the Signal Modules, refer to section *Installing the Hardware* (p.22).

Signal Module: S

The Signal Module: S can be used for monitoring signals from the AFM with external instruments, such as Volt-meters, Oscilloscopes or Spectrum Analysers. The signals are available on nine BNC connectors that are labelled with their signal names. The signal names and their function are listed in the table *Monitor Signals*.

Signal name	Function
X-Axis	X-Position command of the Scanner. Is be affected by Image X-Pos and the Imaging Area Rotation.
Y-Axis	Y-Position command of the Scanner. Is be affected by Image X-Pos and the Imaging Area Rotation.
Z-Axis	Z-Position command of the Scanner. Is affected by the Z-Controller output, Ref. Z-Plane, X- and Y-Slope.
Tip Voltage	The voltage applied to the tip.
Approach	The voltage that determines the speed of the approach motor.
Excitation	The oscillating voltage that is applied to the piezo that excites the cantilever vibration.
Deflection	The raw cantilever deflection signal, contains both the static cantilever deflection and the cantilever vibration.

Monitor Signals

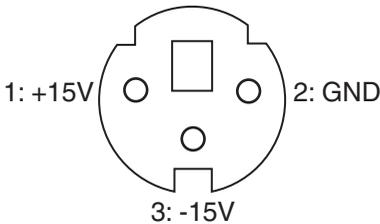
Signal name	Function
Amplitude	The measured cantilever vibration amplitude.
Phase	The measured cantilever vibration phase. The phase is affected by the Reference Phase Mode Property setting of the Phase Contrast Mode.

Monitor Signals

The calibration of the monitor signals can be found by looking up the signal calibration in the Scan Head Calibration Dialog, reached via the menu 'Options>Config Scan Head...'. The magnitude of the physical signal can be calculated from the Monitor Signal voltage using the formula:

$$PhysicalSignal[Unit] = \frac{MonitorSignalVoltage}{10[V]} \cdot Maximum + Offset$$

In addition to the monitor voltages, +15V and -15V voltage sources are available for driving small home-made electronics. The voltages are available on a three-pole mini-DIN connector. The pin-out of this connector is shown in figure [Voltage source connector](#):



Voltage source connector: Connector as seen from outside.

Signal Module: A

The Signal Module: A can be used for adding functionality to the easyScan 2 system in addition to the applications to the Signal Module: S. The signals are available on twenty-one BNC connectors that are labelled with

their signal names. The signal names and their function are listed in the tables *Monitor Signals* and *Signal Module: A Signals*.

Signal name	Function
Sync	An output that can be used to synchronise external equipment with the easyScan 2 controller. This feature can be controlled with the scripting interface. For more information, refer to the Script Programmers Manual, topic ‘Object Reference>Class Scan>SyncOutMode’ and ‘Object Reference>Class Spec>SyncOutMode’
User 1 Output	An analog output that can be used to drive external instruments using the controller. The User output can be used for special spectroscopy measurements.
User 2 Output	An analog output that can be used to drive external instruments using the controller. The User output can be used for special spectroscopy measurements.
X-Axis Input	The Input voltage is added to the X-Position command of the scanner.
Y-Axis Input	The Input voltage is added to the Y-Position command of the scanner.
Z-Axis Input	The Input voltage is added to the Z-Position command of the scanner. If the Z-Controller is turned on, it will try to compensate this voltage, as a result of which the Input voltage will be added to the topography measurement.
Tip Voltage	The input voltage is either added to the Tip-voltage set in the software, or this Input connector has a direct electrical connection to the tip. The second option will be described in more detail in a future manual version (refer to the Nanosurf Web-site).
Excitation Input	The input voltage is either added to the normal Excitation voltage, or only the Excitation Input signal is passed on to the Cantilever Excitation piezo. The second option will be described in more detail in a future manual version (refer to the Nanosurf Web-site).

Signal Module: A Signals

Signal name	Function
User 1 Input	An analog input that can be used to record the signal from external instruments in Imaging and Spectroscopy measurements.
User 2 Input	An analog input that can be used to record the signal from external instruments in Imaging and Spectroscopy measurements.
Aux 1	A connector that can be used for accessing signals that are not otherwise available. Contact your local distributor if you need to use this connector.
Aux 2	A connector that can be used for accessing signals that are not otherwise available. Contact your local distributor if you need to use this connector.

Signal Module: A Signals

The sum of the modulation inputs and the output value (for example of X-Axis) should not exceed the -10V - +10V range. The Excitation signal should not exceed the -5V - +5V range.

In addition, -15V and +15V voltage sources are available for driving small home-made electronics. The voltages are available on the same type of three-pole mini-DIN connector that is used in the Signal Module: S. The pin-out of this connector is shown in figure [Voltage source connector](#).

Using the User Inputs and Outputs

The User Inputs and Outputs can be configured with the User Signal Editor that is reached through the User Input/Output section of the Operating mode panel. This Section is only available in the Advanced Level User Interface. Refer to section [The User Signal Editor](#) (p.98) for a more detailed explanation.

Maintenance

To ensure fault free operation of the microscope the following instructions for maintenance have to be followed.

Scan head

It is very important to keep the sample holder and the open part of the scanner clean. If exposed to moisture (high humidity), corrosion will occur.

- Clean the alignment chip by blowing away dust using dry, oil free air or a soft brush.

Scan electronics

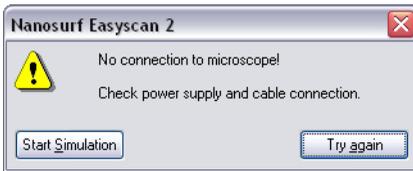
Clean the case and the controls with a soft cloth lightly moistened with a mild detergent solution. Do not use any abrasive pads or solvents like alcohol or spirits.

Problems and Solutions

The problems described here can occur during normal operation of the microscope. If the suggested course of action does not solve the problem, or the problem is not described here, refer to the section *Nanosurf support* (p.81).

Software and Driver problems

No connection to microscope



This error message appears when the easyScan 2 software is waiting for an answer from the controller. Most likely, the easyScan 2 controller is not connected to the mains power, or not turned on. In this case the status lights on the top of the electronics are not on.

- Check the connection and the power switch.

USB Port error



The USB serial converter is not available. The USB cable is not properly connected. In this case the USB power light on the easyScan 2 controller rear panel) does not light up. (figure *The easyScan 2 Controller* (p.19))

- Check if the a second copy of the easyScan 2 is already running and occu-

pying the USB port.

- Check that the USB cable is properly connected.

If this does not solve the problem, check if there is a driver problem with the USB Serial port/USB Serial converter drivers, as described below.

Driver problems

If you have trouble connecting to the controller, or the video image in the positioning window is not available, it is possible that one of the drivers of your instrument is causing problems, for example because the installation did not work, or the installation of some other hardware is in conflict with the drivers of the easyScan 2 controller. In order to solve driver problems:

- Check for driver updates on the Nanosurf Support web site.
- Insert the installation CD for your instrument.
- Log in on an administrator account

Now open the device manager:

- Open the windows menu 'Start>Settings>Control Panel'.

The control panel now opens.

- Click 'Switch to classic view' if you do not see an icon called 'System'.
- Double-click the System icon.

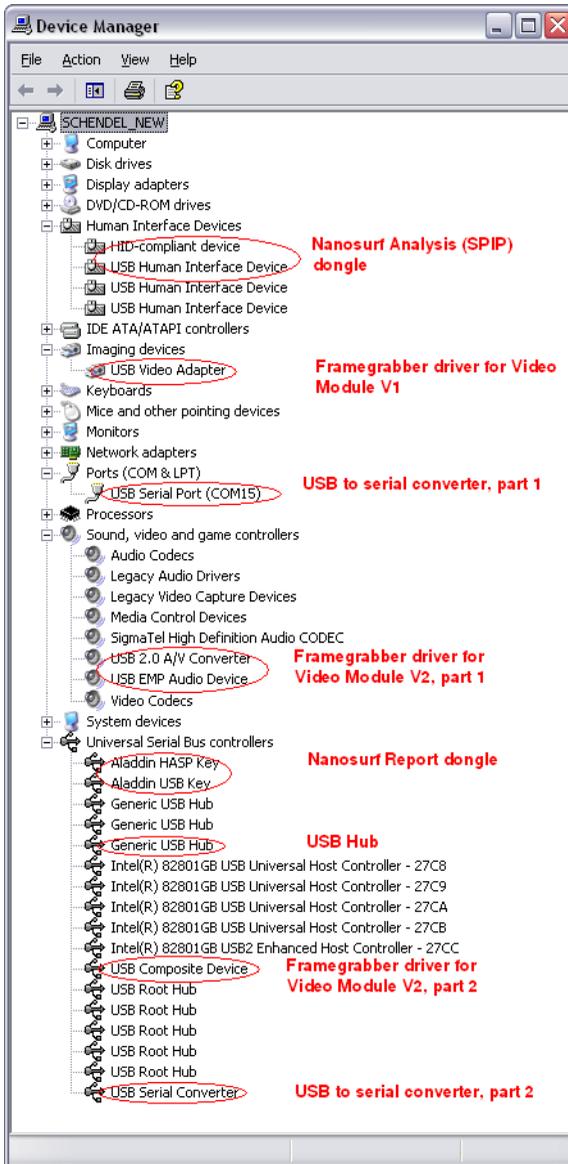
The System properties dialog now opens.

- Select the tab 'Hardware'
- Click the 'Device Manager'-button.

The device manager now opens.

When the device manager opens, and your controller is connected to your computer you may see the drivers shown in figure *Device manager*, depending on the configuration of your controller:

- Generic USB Hub: all controllers
- USB Serial converter, USB Serial port: all controllers



Device manager: The drivers that may be installed on your system when your controller is connected to the computer.

- USB Video Adapter: Video Module version 1
- USB Composite device, USB 2.0 A/V Converter, USB EMP Audio Device: Video Module version 2
- HID-compliant device, USB Human Interface Device: Nanosurf Analysis/SPIP
- Aladdin HASP key, Aladdin USB key: Nanosurf Report

If there are problems with any of these drivers, or a wrong driver is installed, you can try the following to fix it:

- Double click on the driver.

Properties dialog for the device now opens.

- Select the 'Driver'-tab.
- Click the 'Update Driver'-button

Windows will now ask you were to look for the driver.

- Tell windows to take the driver from the Installation CD.

AFM measurement problems

Probe Status light blinks red

This light will blink red when an insufficient amount of light reaches the cantilever deflection detector. This can be either be due to the DropStop still being closed or to a misaligned cantilever chip.

- Check that the cantilever is lying perfectly in the alignment chip.
- Remove the cantilever as described in section *Installing the cantilever* (p.37). Blow away dust from the alignment chip and the cantilever's back side using dry, oil free air. Mount the cantilever again.

For further information, open the Scan Head Diagnosis dialog via the menu 'Options/Check Scan Head...'

Image quality suddenly deteriorates

Tip picks up material

When a scan line suddenly starts reproducing badly, the tip may have picked up some particles:

- Continue measuring for a while (1-2 images), the tip may eventually lose these particles again.
- Retract the cantilever by clicking then perform a new approach.
- Try to induce changes in the tip's end: While measuring increase the force 'SetPoint', or decrease the amplitude 'SetPoint' in the Feedback panel. Restore the set point to its old value when the contrast improves, or if nothing happens after scanning several lines.
- Change the cantilever if no improvement occurs after following these procedures.

Set point drift

When part of the scan line in the Line graph is drawn red, the tip has moved to its maximum or minimum Z-position. This should also be visible in the range display on the right hand side of the graph. The tip will move to its maximum Z-position when it has lost contact with the sample:

- In the Static Force based modes, increase the force Set point, in the Dynamic Force based modes, reduce the amplitude Set point.

If this does not help:

- Click in the Approach panel.

Nanosurf support

Self help

The fastest way to solve a problem is often to solve it yourself. If the previously suggested actions did not help, or the problem is not described here, refer to the Nanosurf support pages:

- Open www.nanosurf.com.
- Click on support.
- Enter the combination of serial number and the password that you received on registering.
- Select the easyScan 2 link.
- If the problem is software related, try to upgrade to the latest version, and/or read the What's new file to see if the problem was solved. For the solution to other problems, refer to the Frequently Asked Questions (FAQ).

If your instrument was not registered already, you will first have to register to get a password.

Assistance

If the standard solutions are not sufficient, contact your local distributor for help. In order to resolve the problem as fast as possible, please provide as much information as possible, such as:

- A detailed description of what happened before the problem occurred. For example: 'When I click the approach button, then quickly click abort, the controller will not react to any I do anything any more. This only happens when measuring in Dynamic Force Mode.'
- If an error message was displayed: The exact text of the message, or at least the start of the message.
- The serial number of your scan head and/or controller.
- A description of the computer hardware and software on which the control software is running: computer brand, type (lap-/desktop), operating system, software version etc.
- Original Nanosurf image data (.nid) files that show the problem, rather than bitmap screen shots, because these files contain all the settings that were used to make them.
- Parameter (.par) files with the instrument settings that were used when the problem occurred.

AFM Theory

Scanning Probe Microscopy

The easyScan 2 AFM is an atomic force microscope, which is part of the family of scanning probe microscopes. When the first scanning probe microscope, the scanning tunneling microscope (STM), it became possible to look into the fascinating world of atoms. The STM was developed by Gerd Binnig and Heinrich Rohrer in the early 80's at the IBM research laboratory in Rüschlikon, Switzerland. For this revolutionary innovation Binnig and Rohrer were awarded the Nobel prize in Physics in 1986.

However, the STM technique is restricted to electrically conducting surfaces. A further development of the STM called the Atomic Force Microscope (AFM) was developed by Gerd Binnig, Calvin Quate and Christoph Gerber. The AFM extended the abilities of the STM to include insulating material. Both the AFM and the STM microscopy techniques work without optical focusing elements. Instead, a small sharp probing tip is scanned very closely across the sample's surface. The distance between the tip and the sample surface is so small that atomic-range forces act between them. In an AFM, tip is attached to the end of a cantilever in order to measure these forces. The force acting on the tip can then be determined by detecting the deflection of this cantilever.

The measurement of the cantilever deflection can be used to control the tip-surface distance on an atomic scale. Thus, enormous resolution can be achieved, so that even the atomic arrangement of surfaces can be probed. This measurement is a so-called static measurement mode, in which the static deflection of the cantilever is used. Generally, the forces acting on the tip will cause it to snap onto the sample, which result in an effective, nanometer-range flattening of the tip, and friction and stiction between the tip and the sample.

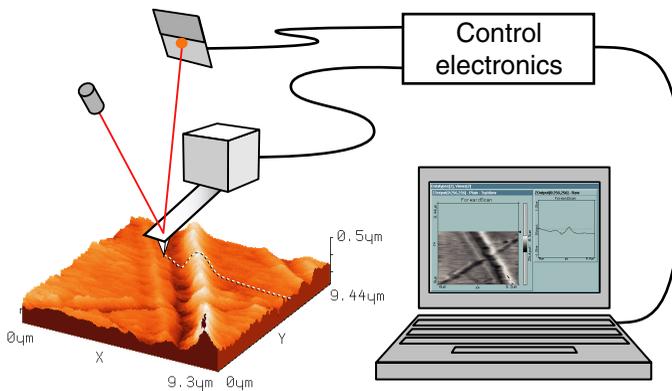
To circumvent the aforementioned problems, the so-called Dynamic force microscopy modes can be used, as was pointed out by the AFM's inventors. The cantilever vibrates during the operation in these measurement modes. In the dynamic modes, changes in the free resonance frequency and the

damping of the cantilever vibration caused by the forces between the tip and the cantilever can be measured and used for controlling the tip-sample distance.

To achieve atomic resolution, ultra-clean and flat surfaces prepared in highly sophisticated vacuum systems are needed. Nevertheless, measurements in air can give useful results for many technically relevant surfaces. In this manual, the use of the dynamic modes in air on such technically relevant surfaces is described.

The Nanosurf easyScan 2 AFM

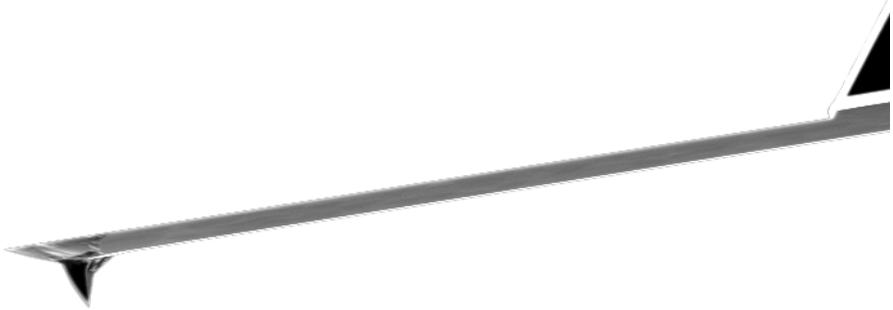
The easyScan 2 AFM is an AFM that can be used in both static and dynamic operating modes. The AFM cantilever is a micro fabricated canti-



easyScan 2 AFM system: Computer, Cantilever with deflection measurement system scanning the sample.

lever with an integrated tip mounted on a cantilever holder chip (see figure [Cantilever](#)).

When the sensor tip comes in contact with the sample, a repulsive force that increases with decreasing tip-sample distance acts on it. In the static force operating mode, the bend of the cantilever, due to the force acting on its tip, is measured using a laser beam deflection system.



Cantilever: 228 μm long micro-fabricated silicon cantilever with integrated tip

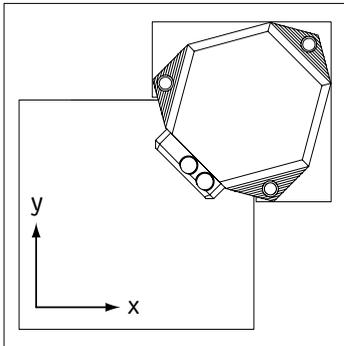
In dynamic operating modes, the cantilever is excited using a piezo element. This piezo is oscillated with a fixed amplitude at an operating frequency close to the free resonance frequency of the cantilever. The repulsive force acting on the tip will increase the resonance frequency of the cantilever. This will cause the vibration amplitude of the cantilever to decrease. The vibration of the cantilever is also detected using the laser beam deflection system.

The measured laser beam deflection or cantilever vibration amplitude can now be used as an input for a feedback loop that keeps the tip-sample interaction constant by changing the tip height. The output of this feedback loop thus corresponds to the local sample height.

An image of the surface is made by recording the sample height as the tip is scanned over the sample surface in the x and y direction. The direction of the x - and y -axes of the scanner is shown in the figure [Scanner coordinate system](#). The scanner axes may not be the same as the measurement axes, when the measurement is rotated, or when the X or Y measurement plane is changed. Therefore, the image x - and y -axes are denoted by an asterisk to avoid confusion (i.e. X^* , Y^*).

The sample structure image is now obtained by recording the output of the height control loop as a function of the tip position.

AFM THEORY



Scanner coordinate system

The user interface

This chapter explains the general concepts of the user interface that controls the functions of the easyScan 2 software. These functions are:

- Setting up the Nanosurf easyScan 2 AFM hardware,
- moving toward the measurement position,
- performing measurements,
- displaying the measurement results,
- evaluating the measurements,
- permanently storing measurements and instrument.

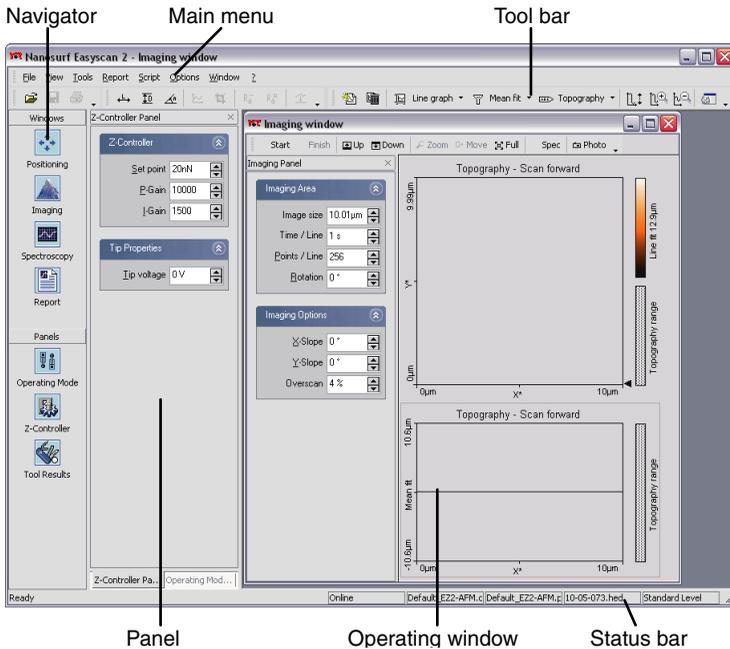
These functions can be accessed via the easyScan 2 software, which is called 'workspace'. In the following, the workspace will be explained first, then the actual functions of the software will be discussed in more detail. The workspace of the easyScan 2 software consists of the following parts:

1. The main window,
2. operating windows,
3. measurement document windows,
4. tool bars,
5. control panels.

The main window

The main window is opened as soon as the easyScan 2 software starts. It gives access to the whole functionality of the easyScan 2 software, and contains all other windows:

- The Main menu.
- Operating windows that are used to perform specific operations with the microscope.
- Measurement document windows that are used to evaluate previously made measurements.



The main window

- Several tool bars that are used to issue commands.
- Several control panels that are used to set measurement parameters.
- The Navigator that is used to quickly select between the most often used operating windows and panels.
- The Status bar that displays the state of the instrument.

Operating windows

Operating windows are used to perform specific operations with the microscope. These operations are controlled using specific panels and tool bars that are part of these windows. The Operating windows are:

- Positioning window: positioning the tip with respect to the sample, with the aid of the built-in optical microscope (chapter *Positioning* (p.115)).

- Imaging window: generating images of the sample (chapter *Imaging* (p.120)).
- Spectroscopy window: measuring various 'A as a function of B' curves at certain sample locations, such as force-distance curves, or current-voltage curves (chapter *Spectroscopy* (p.128)).

Measurement document windows

The Measurement document windows visually represent previously made measurements. They are created when you decide to keep the current measurement result. The measurement documents are used for storing, loading, printing and evaluating measurements. The measurement document is described in more detail in the chapters *Viewing measurement data* (p.134) and *Storing measurements and further data processing* (p.151).

Tool bars

The tool bars can either be free floating windows (figure below, left), or they can be 'docked' to the top or the sides of the window they are associated with (Figure below, right).



Most tool bars dock to the Main window, some dock to a task specific window.

Arranging tool bars

The tool bars have several features that allow you to arrange them in a way that is most efficient for your application.

To display a tool bar that is invisible, select the window it is associated with, and tick the tool bar's name in the View menu.

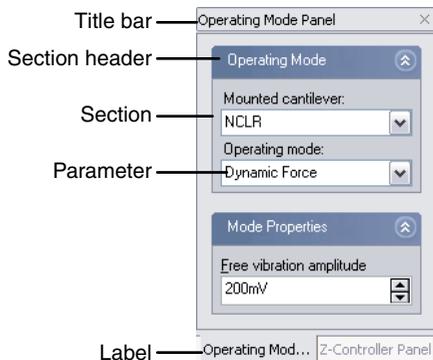
To dock a tool bar to the sides of its associated window, or to the side of, or below another tool bar that is already docked to this window, drag its title bar using the mouse cursor.

To move a docked tool bar, use the mouse cursor to drag its handle on the left side of the tool bar. When the mouse cursor is over the handle, the cursor changes to a four pointed arrow.

To un-dock a docked tool bar, double click its handle, or drag the handle outside the area reserved for tool bars on the sides of its associated window.

Control panels

Just like the tool bars, control panels can be either be free floating windows, or they can be ‘docked’ to the sides of the window they are associated with. Most control panels dock to the Main window, some dock to a task specific window. The control panels give access to specific functions of the easyScan 2 AFM. The control panels contain one or more function sections, that can be collapsed and opened by clicking on the section header.



A stack of panels

The number of visible sections and the number of visible parameters depends on the user interface mode selected in the User Interface Configuration dialog (section *The User Interface Dialog* (p.94)). To see in which user interface mode a certain parameter is available, look at the title of the manual section in which it is described.

Arranging control panels

The control panels have several features that allow you to arrange them in a way that is most efficient for your application.

A control panel associated with the main window is opened and brought on top of the other windows by clicking on its icon in the navigator. Any control panel can be opened and brought on top of the other windows, by selecting the window it is associated with, and ticking the panel's name in the View menu.

Control panels can be stacked to save display space. When panels are stacked, labels are displayed on the bottom of the control panel stack. To put a control panel on top of the stack, click its label. To add a control panel to a stack, drag either its title bar or its label to either the title bar or labels of the stack. To remove a panel from a stack, drag its label away from the stack.

To dock a (stack of) panels to the side of its associated window, or to the side of, or below another panel that is already docked to this window, drag its title bar to the desired position using the mouse cursor.

It is possible to scroll the content of a control panel up and down, when it is too small to display all the parameters it contains. To do this, move the mouse cursor over an area where it changes to a four pointed arrow. Then, drag the content up and down with the mouse cursor.

Storing and retrieving the workspace

When panels are opened, they appear at predefined places in the main window. This arrangement of the 'workspace' is stored in the configuration file 'Default EZ2-AFM.gui' or 'Default EZ2-STM.gui' by default. The location of the configuration files on the hard-disk depends on the operating system you use. Functions for storing and retrieving the workspace are accessed via the menu 'File>Workspace'.

'Save' saves the workspace to the currently selected workspace file.

'Save as...' saves the current arrangement of the panels under another name.

'Load' loads a previously saved workspace.

Entering values in the control panels

To change a parameter in any panel, use one of the following methods:

- Activate the parameter by clicking it with the mouse pointer, or by selecting it with the Tab key.
- The value of an activated parameter can be increased and decreased using the up and down arrow keys on the keyboard. The new value is automatically used after one second.
- The value of a numerical parameter can also be increased and decreased by clicking the arrow buttons  with the mouse pointer. The new value is automatically used after one second.
- The value of an active numerical parameter can also be entered using the keyboard.

The entered value is used on pressing the 'Enter' or 'Return' key, or by activating another input.

The entered value is discarded on pressing the 'Esc' key.

Type the corresponding character to change the unit prefix:

prefix	keyboard key	prefix	keyboard key
femto	f	no prefix	space bar
pico	p	kilo	k
nano	n	mega	shift - M
micro	u	giga	shift - G
milli	m	tera	shift - T

Unit prefixes with corresponding character

For example, if the basic unit is Volts, type 'm' to change to millivolts, type the space bar for volts, type 'u' for microvolts.

- The selection of a drop-down menu (e.g.: ) can be changed using the mouse or the up and down arrow keys on the keyboard.

Sometimes the program will change an entered parameter value to a slightly different value. This happens when the desired value is outside the range that the easyScan 2 Controller can handle, for example due to the resolu-

tion limits or timing limits. The desired value is automatically changed to the nearest possible value.

Storing and retrieving measurement parameters

All measurement parameters are stored in a configuration file with the extension '.par'. When the easyScan 2 software is started, default values are loaded from a file that is selected in the Controller Configuration Dialog (section *The Controller Configuration dialog* (p.110)). Functions for storing and retrieving parameters are accessed via the menu 'File>Parameters'.

'Save' saves the parameters to the currently selected parameter file. The name of this file is indicated in the status bar at the bottom of the main window.

'Save as...', saves the parameters under a new file name.

'Load' loads a previously saved parameter file.

IMPORTANT

When you have not loaded another file, 'Save', will overwrite the original default parameter file with you current settings.

The User Interface Dialog



The User Interface dialog is opened via the menu ‘Options>Config User Interface...’

Program Skin

Select the look of the easyScan 2 software you are most comfortable with. All screen-shots in this manual were made with the Windows XP skin.

User Interface Mode

Determines the number of parameters displayed in the various panels:

Easy level only those parameters that are absolutely necessary to do a measurement

Standard level the commonly useful parameters

Advanced level all available parameters

Options

Save workspace on exit

When active, the workspace settings are saved to the system registry when the software is exited (section *Storing and retrieving the workspace* (p.91))

Animated menu

When active, the opening of the menu is nicely animated.

Hardware setup

Some changes to the hardware setup must be made during the operation of the microscope. Other changes are generally only made when the hardware is changed. The Operating mode panel and the Z-Controller panel are used to change the hardware setup during the operation of the instrument. The rest of the hardware setup is distributed over several dialogs that are reached via the Options menu. These panels and dialogs are discussed in this chapter.

The Operating mode panel

The operating mode panel allows you to select the operating mode that you wish to use, and to set up several operating mode related parameters. The operating mode determines which signals are measured, and which signal is used to control the Z-position. To open the Operating mode panel, click



in the navigator.

The number of available modes depends on the Scan head and on the modules built into the easyScan 2 controller. The modules required to be able to use a certain operating mode are listed in table *Operating modes and required modules*. The modes can be divided into the static operating modes that control the Z-position using the Cantilever deflection, the dynamic operating modes that control the Z-position using the vibration amplitude, and the STM mode that controls the Z-position using the tunnelling current.

Operating mode	Required modules
STM	STM scan head
Static force	AFM Basic
Dynamic force	AFM Basic, AFM Dynamic
Phase contrast	AFM Basic, AFM Dynamic, AFM Mode Extension
Force Modulation	AFM Basic, AFM Dynamic, AFM Mode Extension
Spreading Resistance	AFM Basic, AFM Dynamic, AFM Mode Extension

Operating modes and required modules

The signals measured with each of the operating modes are listed in table *Operating modes and measured signals*. Note that the names of the signals can be changed in the ‘Scan Head Calibration’ dialog.

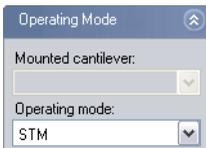
Operating mode	Signals measured
Static force	Topography, Cantilever deflection(, User Input 1, User Input 2)
Dynamic force	Topography, Vibration amplitude(, User Input 1, User Input 2)
Phase contrast	Topography, Vibration amplitude, Vibration phase(, User Input 1, User Input 2)
Force modulation	Topography, Cantilever deflection, Vibration amplitude(, User Input 1, User Input 2)
Spreading Resistance	Topography, Cantilever deflection, Tip current(, User Input 1, User Input 2)
STM	Topography, Tip Current (User Input 1, User Input 2)

Operating modes and measured signals: The User Inputs are only available when they are enabled and the Signal Module: A is installed.

STM mode

This mode is only available when an STM head is connected to the controller. In this case, it is the only available mode setting.

Operating mode (Easy, Standard, Advanced)



Mounted cantilever (Easy, Standard, Advanced)

Not available, this input is only used for AFM modes.

Operating mode (Easy, Standard, Advanced)

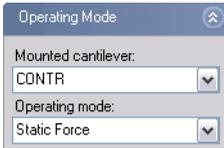
STM mode by default.

User Input/Output (Standard, Advanced)

See the description under Static Force mode.

Static Force mode

In the static force mode, the Operating Mode and User Input sections are available.

Operating mode (Easy, Standard, Advanced)**Mounted cantilever (Easy, Standard, Advanced)**

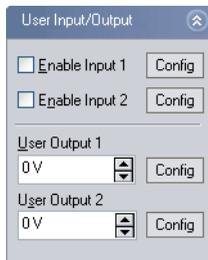
The mounted cantilever type. The mounted cantilever type is used to automatically determine the search range in the dynamic operating modes, and to determine the correct calibration for the force set point in the static operating modes.

Operating mode (Easy, Standard, Advanced)

Changes the operating mode.

User Input (Standard, Advanced)

Enable User Input1, 2



When active, the data from the User input (chapter *The Signal Modules* (p.72)) is measured and stored. Enabling the user inputs significantly increases the measurement file size.

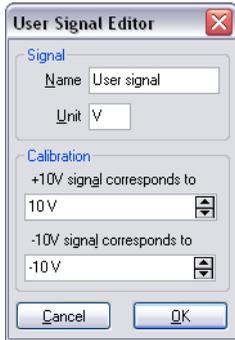
User Output 1, 2

The output value of the user output.

Config...

Opens the User Signal Editor dialog.

The User Signal Editor



The User Signal Editor dialog is used for editing the calibration of the User input signal. It can be reached through the User Input/Output section of the Operating Mode Panel. The settings made in this dialog are stored in the Scan head calibration file.

Signal

Name

The name of the user signal. This name is used throughout the program to refer to the user signal.

Unit

The base unit of the physical signal, without prefix (i.e. m, not nm or μm).

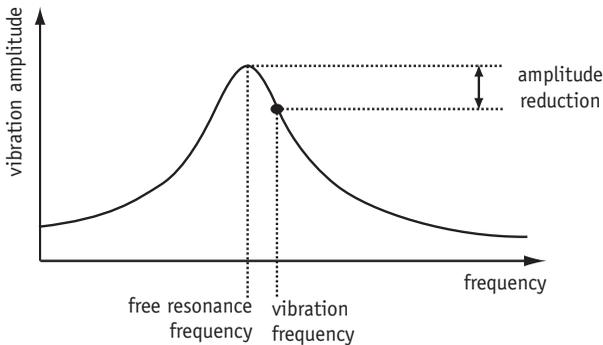
Calibration

The physical signal values that correspond to the maximum and minimum signal voltages should be entered here. Prefixes can be used here.

Dynamic Force mode

In addition to the same Operating mode and the User Input section as in the static operating mode, two sections of parameters may be available, depending on the user interface mode.

The dynamic force mode parameters can either be set manually or determined using an automatic search procedure. The automatic search starts with the coarse measurement of a cantilever resonance curve (figure *Determination of the vibration frequency*). Throughout this measurement, the



Determination of the vibration frequency

cantilever is excited with a fixed amplitude, whilst the excitation frequency is varied. The resonance curve contains a measurement of the resulting cantilever vibration as a function of the excitation frequency. When the search is successful, the resonance curve contains a single peak at the free resonance frequency of the cantilever. Afterward, a second, fine-tuning search is performed in a 3 kHz frequency range around the resonance frequency detected in the coarse search.

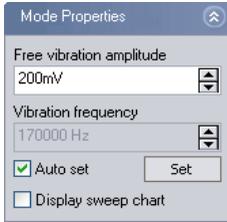
The computer adjusts the value of Vibration frequency so that the cantilever vibration amplitude is reduced by the amount set in 'Amplitude reduction' in the Freq. Peak Search section.

Mode Properties (Easy, Standard, Advanced)

Free vibration amplitude (Easy, Standard, Advanced)

The desired reference amplitude of the cantilever vibration. The cantilever vibrates at this amplitude when it is far away from the sample. The excita-

HARDWARE SETUP



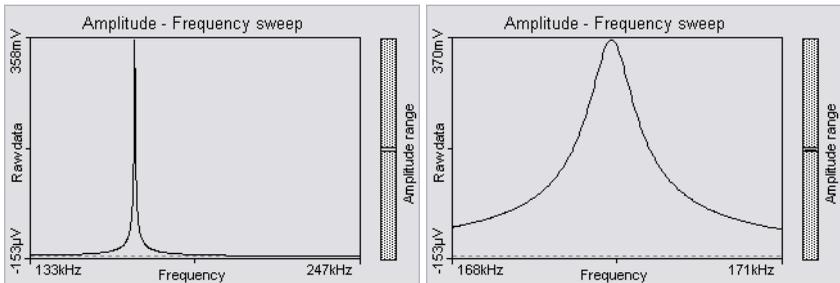
tion strength is adjusted so that this vibration amplitude is reached.

Vibration frequency (Standard, Advanced)

The frequency at which the cantilever vibrates during the measurement. This frequency can automatically be set as described at the start of this section. When 'Auto set' is enabled, the Vibration frequency is automatically set each time an approach is started. Clicking starts the automatic setting immediately.

Display sweep chart (Standard, Advanced)

When active, the results of the vibration frequency search measurements are transferred to a measurement document, and displayed on the screen.



Cantilever resonance curve: left: coarse search; right: fine-tuning search

Freq. peak search (Advanced)

The parameters for the automatic vibration frequency search are set here.

Start frequency (Advanced)

The start frequency for the coarse search

End frequency (Advanced)

The end frequency for the coarse search



Step frequency (Advanced)

The difference between two frequency points at which the cantilever vibration amplitude is measured during the coarse search. If the increment is large, the search takes less time. When however the increment is too large, there is a risk that the resonance frequency may not be found.

Auto set (Advanced)

When active, the range and frequency increment are automatically set to suitable values for currently selected cantilever type.

Amplitude reduction (Advanced)

Indirectly determines the 'Vibration Frequency' in the 'Auto set' mode: The computer adjusts the Vibration frequency so that the cantilever vibration amplitude is 'Amplitude reduction' percent smaller than the vibration amplitude at the resonance frequency.

Use upper sideband (Advanced)

When active, the vibration frequency is set larger than the resonance frequency. Otherwise, the vibration frequency is set smaller.

Phase Contrast mode

In addition to the parameters in the Dynamic Force operating mode, the Reference Phase is available in the Standard and Advanced user interface modes.

Reference Phase (Standard, Advanced)

The reference phase for the detected cantilever vibration. Changing the reference phase changes the offset of the phase signal. The phase reference can

be automatically set so that the phase signal is zero. When ‘Auto set’ is enabled the phase reference is automatically set after finishing the approach. Clicking starts the automatic setting immediately.

Force Modulation mode

In addition to the parameters in the Static Force operating mode, two additional parameters are available.

Excitation amplitude

The amplitude of the sensor excitation during a force modulation mode measurement.

Excitation frequency

The frequency of the sensor excitation during a force modulation mode measurement. Clicking starts a measurement of the cantilever resonance curve, that helps you to select the excitation frequency. The settings for this measurement are the same as those for the Dynamic Force measurement.

Spreading Resistance mode

The operating mode panel for the Spreading Resistance mode is the same as that for Static Force operating mode.

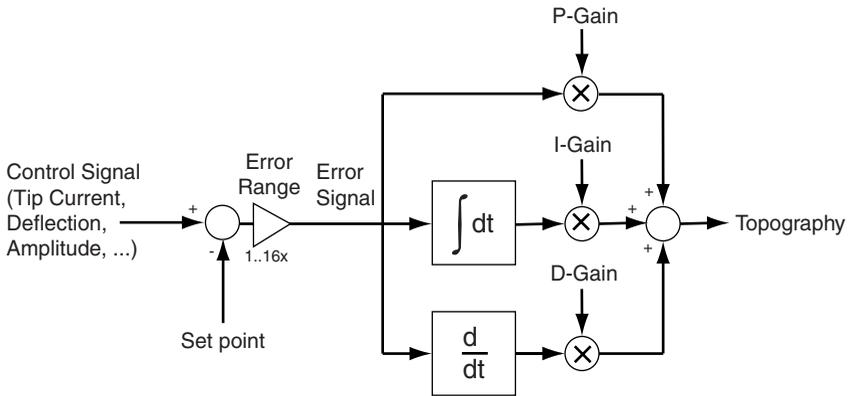
The Z-Controller Panel

The tip-sample interaction is normally kept constant using the Z-Controller. The Z-Controller is a PI(D) controller as is shown in figure [Z-Controller](#). The settings of this controller are set in the Z-Controller panel. To open the Z-Controller panel, click  in the Navigator.

Z-Controller (Easy, Standard, Advanced)

Set point (Easy, Standard, Advanced)

The working point for the Z-Controller. Depending on the operating mode, this is the tunneling current (STM mode), cantilever deflection (static force mode) or relative cantilever vibration amplitude (dynamic force mode). In the latter case, the set amplitude is relative to the operating amplitude, set in the Operating mode panel. For example, when a set point



Z- Controller



of 70% is used, the Z-Controller will move the tip closer to the sample until the vibration amplitude has decreased to 70% of the vibration amplitude far away from the sample.

Loop-Gain (Easy)

The speed of the Z-Controller. If the gain is too low, the Z-Controller will not follow the surface fast enough. Thus, the image will not be as sharp as it could be. If the gain is too high, the Z-Controller will overshoot and may start to oscillate. Thus, the image will contain many measurement artifacts.

P-Gain (Standard, Advanced)

The strength of the Z-Controller reaction that is proportional to the error signal. Increasing the P-Gain decreases the error signal.

I-Gain (Standard, Advanced):

The strength of the Z-Controller reaction that is proportional to the integral of the error signal. Increasing the I-Gain decreases the error signal over time. It is the least sensitive to noise, and usually the dominant contributor

to the topography measurement.

D-Gain (Advanced)

The strength of the Z-Controller reaction that is proportional to the derivative of the error signal. Increasing the D-Gain decreases fast changes in the error signal, but also amplifies high frequency noise. The D-Gain is only available in the ‘Standard PID’ Z-feedback mode of the Z-Controller (see following section).

Z-Controller Mode (Advanced)



Z-Feedback Mode

- Free Running** The Z-Controller is active.
- Freeze Position** The Z-Controller is not active, the scanner remains in its current Z-position.
- Stop and Clear** The Z-Controller is not active, the scanner is moved to the ‘Ref. Z Plane’, set in the Imaging Panel.

The *Probe Status light* will blink green as long as the Z-Controller is deactivated.

IMPORTANT

The tip may be damaged when the Z-Controller is not active during scanning. This will definitely happen when Ref. Z Plane is much lower than the current position of the tip, or when the scan range contains large height differences.

Z-Feedback algorithm

- Standard PID** A standard PID controller is used for Z-Feedback.
- Adaptive PI** A standard PI controller is used for feedback. In addi-

tion, the bandwidth of the Topography measurement is adapted to the number of measured points per second.

The adaptive PI controller reduces noise in the measurement. However, topography changes that happen faster than the time between two measured points are also lost. This makes it more difficult to detect vibrations due to instability of the feedback loop. These vibrations remain visible in the Current, Amplitude or Deflection signal. Therefore, always monitor these signals when optimising Z-Controller settings, especially when using the Adaptive PI setting.

Error Range (Advanced)

The range of the error signal used to control the Z-Position. The error signal is the difference between the signal used for topography feedback and the current set point. When the value of 'Error Range' is reduced, the resolution of the error signal is increased.

Tip Properties (Standard, Advanced)



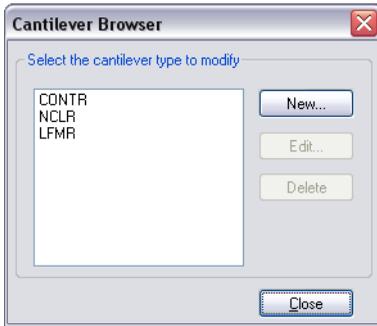
Tip Voltage (Standard, Advanced)

The potential to be applied to the tip. The usable voltage range is between -10V and +10V. In the STM, the sample is automatically connected to the ground of the instrument. In the AFM, the sample has to be electrically connected to the instrument chassis ground for accurate measurements.

Cantilever types configuration

The cantilever types that you can select from in the Operating Mode Panel are configured using two dialogs: The cantilever browser, and the cantilever editor dialog. The cantilever types configuration is stored in a file called 'cantilever.ini', located in the local settings directory of the user logged on to the PC.

The cantilever browser dialog



The cantilever browser dialog is opened via the menu ‘Options>Config Cantilever Types...’. The cantilever browser allows the editing and creation of cantilever types.

New

Opens the cantilever editor dialog for a new cantilever type. You can create new cantilever types that are not defined in the default configuration. The AFM head requires the following cantilever properties:

- The bottom of the sensor chip must have grooves that fit into the alignment chip.
- The cantilever should have a nominal length of 225 μm or more, and a width of 40 μm or more.
- The back of the cantilever must have a coating that reflects infrared light. Uncoated cantilevers transmit much of the infrared light of the deflection detection system.

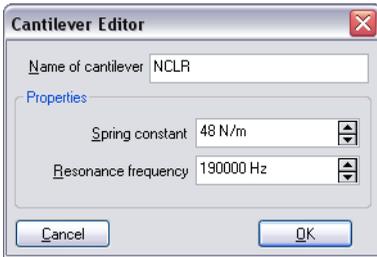
Edit...

Opens the cantilever editor dialog to modify the currently selected cantilever type.

Delete...

Deletes the currently selected cantilever type using the cantilever editor dialog.

The cantilever editor dialog



The following properties of a cantilever type are entered in this dialog:

Name of cantilever

The name of the cantilever type. This name appears in the cantilever browser and the Cantilever type drop-down in the Operating Mode Panel.

Spring constant

The (nominal) spring constant of this cantilever type. This value is used to calculate the correct force Set point in the operating modes that use the static force for Z-Control. (section *Static Force mode* (p.97))

Resonance frequency

The (nominal) resonance frequency of the cantilever type. This frequency is used for the calculation of the automatic resonance frequency search range (section *Dynamic Force mode* (p.99)).

Scan head configuration

The scan head configuration is used to store all calibration values specific to a certain scan head. The configuration of each scan head is stored in a file with the extension '.hed'. This file is copied from the software installation CD on installation of the instrument. When you change the scan head, you should also load the correct configuration file.

The scan head selector dialog

The scan head selector dialog is opened via the menu 'Options>Config Scan Head...'.

Load...

Loads a different scan head configuration file.

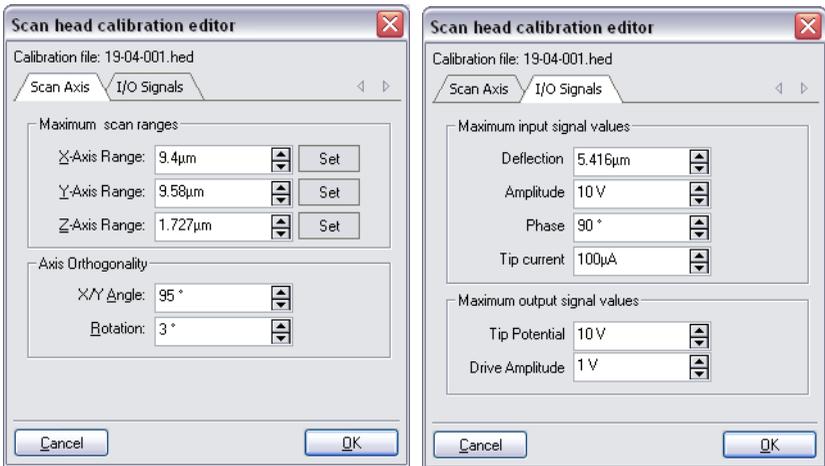
Save as...

Saves the current scan head configuration under another name.

Edit...

Edit the currently loaded scan head configuration using the scan head calibration dialog. Always save a backup of the Scan head configuration by clicking ‘Save As...’.

The scan head calibration editor



In this window the calibration of all standard Inputs and Outputs can be configured individually along with some scanner. The configuration of the User inputs and outputs is located in a different dialog (section *The User Signal Editor* (p.98)).

IMPORTANT

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

Scan Axis, Maximum scan ranges**X/Y/Z-Axis Range**

The calibration values of each of the scanner axes. The calibration values are given as the maximum motion range of the scanner (when Overscan is set to 0%).

Set

Opens the scan axis correction dialog (see next section).

Scan Axis, Axis Orthogonality

The X- and Y-Axes of the scanner are generally not perfectly orthogonal, and their orientation with respect to the AFM housing may vary. The easy-Scan software corrects these errors by adding/subtracting some of the X scanner command signal to the Y scanner command signal and vice versa.

X/Y Angle

The angle between then the X and Y axis of the scanner hardware. The software uses this value to correct the scan command signals such that the scan axes are orthogonal.

Rotation

The angle between the X axis of the scanner and the X axis of the microscope body (figure *Scanner coordinate system* (p.86)). The software uses this value to correct the scan command signals such that the scan axis is parallel to the X axis of the microscope body.

I/O Signals, Maximum input signal values**Deflection**

The calibration of the cantilever deflection signal.

Amplitude

The calibration value of the cantilever vibration amplitude signal.

Phase

The calibration value of the cantilever vibration phase shift signal.

Tip current

The calibration value of the internal Tip current measurement

I/O Signals, Maximum output signal values

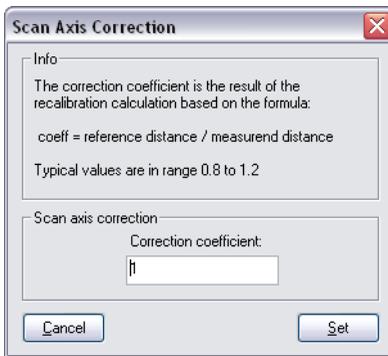
Tip Potential

The calibration value of the Tip voltage setting.

Drive Amplitude

The calibration value of the Amplitude of the signal that is used to excite the cantilever. The Drive Amplitude signal is only displayed in the Data Info Panel.

The Scan Axis Correction Dialog



This dialog can be used to multiply the scan axis calibration factor by a correction coefficient that has been determined by evaluating the measurement of a calibration gird, for example using SPIP/Nanosurf Analysis.

Scan axis correction

The Scan range is multiplied with this number when the 'Set'-Button is clicked.

The Controller Configuration dialog

The Controller configuration dialog is opened via the menu 'Options>Config Controller...'. On a correctly configured system, it should not be necessary to change the settings in this dialog, except for the start-up parameters and chart arrangement file configuration.



Start configuration

The parameter and chart arrangement files that are loaded when the software starts (section *Storing and retrieving the chart arrangement* (p.135)).

USB Connection

The easyScan 2 controller uses a virtual serial port that is connected to the USB port. The number of this virtual serial port should be the same as the one shown in your the windows device manager dialog.

Video Signal

The configuration of the easyScan 2 controller's internal video capture device. The default configuration should normally not be changed. This feature is only available when the video camera is installed.

Microscope Firmware

Click the Update button to install firmware updates that you receive from Nanosurf support.

The Edit Access Codes Dialog



The Edit Access Codes Dialog is used to enter the access code for software modules. At the moment, the only software module is the scripting interface. The dialog is accessed via the menu entry ‘Options>Config Access Codes...’

The Scan head Diagnosis dialog

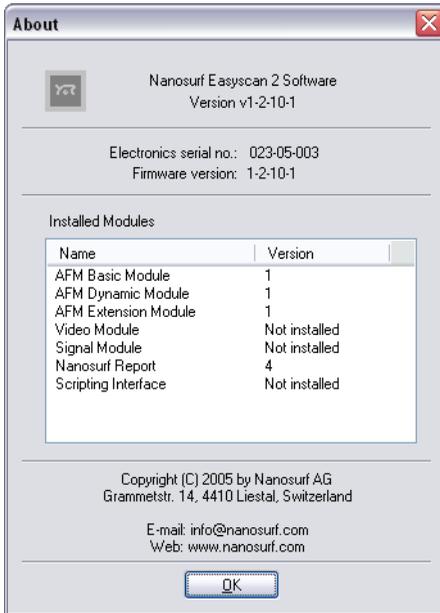
The Scan head Diagnosis dialog is opened via the menu ‘Options>Check Scan Head...’. In it, the controller reports the current status information of the sensor or the approach platform. If the Status light on the easyScan 2 controller is blinking red, more detailed information about the failure is displayed in the ‘Microscope Diagnosis’ dialog.

Simulate Microscope

Check or uncheck the menu item ‘Options>Simulate Microscope’ to enter and exit the simulation mode. Once the simulation mode is active, the first field in the status bar of the easyScan 2 software displays the text ‘Simulation’, otherwise this field displays the text ‘Online’.

In the simulation, many functions of the microscope are performed on a mathematically generated surface. Thus, the software functionality and working methods of the microscope can be practised.

The About dialog



The About dialog displays various information that may be useful for diagnostics when you have problems with your instrument. To open the About dialog:

- Select the menu entry '¿>About...'

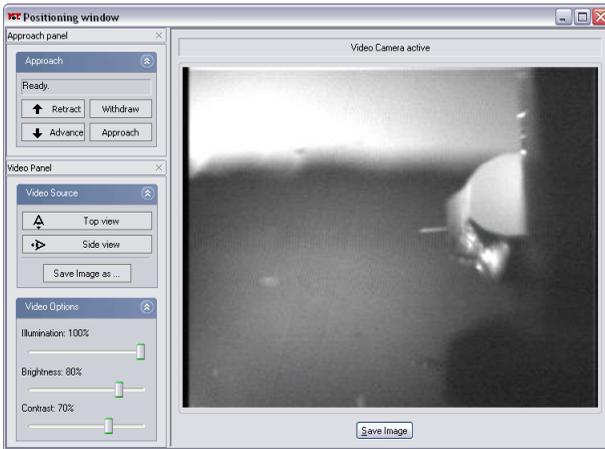
The about dialog contains the following information:

- the version number of the control software
- the serial number of the controller
- the version number of the firmware that is running on the controller
- the version number of the built-in modules

- contact information for getting more support.

When the microscope simulation is active, the about dialog displays the serial number '000-00-000' is displayed. The Nanosurf Web site and contact address for information and software updates are also displayed here.

Positioning



The Positioning window contains all the software tools for positioning the tip with respect to the sample:

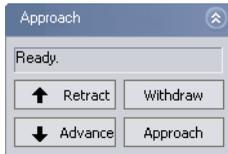
- The Approach panel
- The Video panel (with the Video Module)
- The Video display (with the Video Module)

Click  in the Navigator to open the Positioning window.

The Approach panel

The motor for the tip-sample approach is operated using the 'Approach Panel'.

Approach (Easy, Standard, Advanced)



Status

Displays the current status of the approach stage.



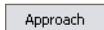
Increases the tip-sample distance at maximum speed until the button is released.



Decreases the tip-sample distance at maximum speed until the button is released.

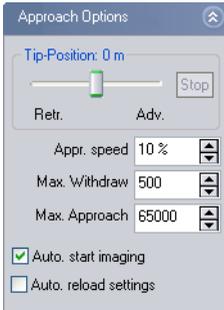


Increases the tip-sample distance with the settings given in the Approach Options.



Starts the automatic approach. During the automatic approach, the tip-sample distance is decreased until the Set point, set in the Z-Controller panel, is reached, or until the maximum approach time is reached.

Approach Options (Standard, Advanced)



Tip-Position (Advanced)

Determines the Z-Position of the scanner when the approach motor stops. When the Tip-Position is changed when the tip is already approached to the sample, the motor will move the approach stage so, that the Z-Position of the tip becomes equal to the set Z-Position. When a high resolution (2 μm Z-Range) scanner is used, the Tip-Position before the approach is set to +500 nm Advanced by default. This compensates for the residual motion of the approach stage that occurs after the approach motor has stopped.

CAUTION

Changing the Z-Position when the tip is approached to the sample may cause tip damage when using high resolution scanners. This can be due to play in the approach stage, which is caused by a change in the initial load of the approach stage bearings. Contact your local Nanosurf representative if this seems to be the case.

The Tip-Position setting can for example be useful when a sample is mainly a large flat surface with some deep holes in it. In this case proceed as follows:

- Ideally, first make sure that the center position of the Scan range is outside a hole.

When the Scanner is idle (such as during approach), the tip is always brought to the center position of the scan range.

- Set Tip-Position to about 80% of the maximum value.

- Click Approach

The Tip-Position setting can not be used with STM scan heads, which is due to the different approach motor used in the STM.

Stop button

Stop the adjustment of the height

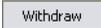
Appr. speed (Standard, Advanced)

The speed of the motor during the automatic approach and withdraw. When an STM scan head is used, the Approach speed changes the Step size of the approach motor, the step frequency is determined by the speed of the feedback loop.

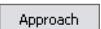
CAUTION

If the approach is too fast, the tip or the sample surface can be damaged. On the other hand, the motor will not move when Appr. speed is too small.

Max. Withdraw (Standard, Advanced)

The maximum withdraw duration after clicking .

Max. Approach (Advanced)

The maximum approach duration after clicking .

Auto. start imaging (Standard, Advanced)

When selected, the system automatically starts imaging after a successful approach. Scanning is automatically stopped when the approach motor is moved.

Auto reload settings (Advanced)

When selected, the software reloads the default start-up parameter file each time an approach is started (section *The Controller Configuration dialog* (p.110)).

The Video panel

The video panel controls the video display in the Positioning window. Changing these settings only has effect when a Video camera is fitted on your system.

Video source



The video source section determines which video signal is currently displayed.



Switches the video display to the top view.



Switches the video to the side view.



Saves the currently displayed image to a JPEG file that is selected using a Save file as... dialog.

Video Options



The Video Options section determines how the video signal is displayed. There are separate sets of options for the side and the top view.

Illumination

The intensity of the sample illumination on the scan head.

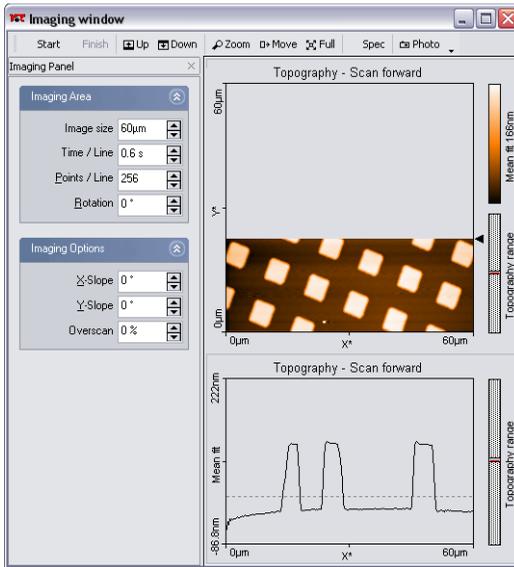
Brightness

The brightness of the video display

Contrast

The contrast of the video display

Imaging



The imaging window

Imaging measurements of the sample are controlled using the Imaging window. The Imaging window can be opened by clicking  in the navigator. The Imaging window contains the Imaging bar, with commands that control the imaging processes, and the Imaging panel, with parameters that determine how the imaging is done.

The Imaging window also contains a number of charts that display the data from the ongoing measurement. The imaging window can display as many charts as the size of the window can accommodate. By default, two charts are displayed, a Line graph, and a Color map of the sample's Topography. For more information on adding and changing charts (chapter [Viewing measurement data](#) (p.134)).

The imaging bar

Start / Stop

Start starts a measurement and then changes to **Stop**. Clicking **Stop** aborts the measurement as soon as the current scan line is finished.

Finish

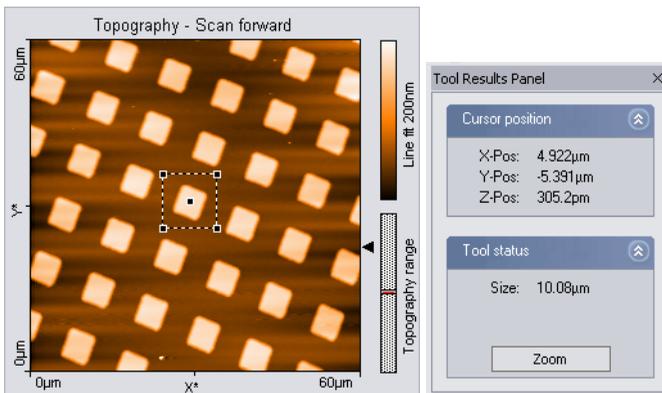
After clicking **Finish** the measurement stops when the current measurement has finished.

Up / Down

Starts a single measurement or changes the scanning direction of the measurement in progress. With **Up** the image is scanned from the bottom to top, with **Down** it is scanned from the top to the bottom. If a measurement has been started using **Up** or **Down** the measurement stops automatically after one full image.

Zoom

Selects an area that is to be measured in more detail. The size and area of the area is displayed in the Tool Results panel.



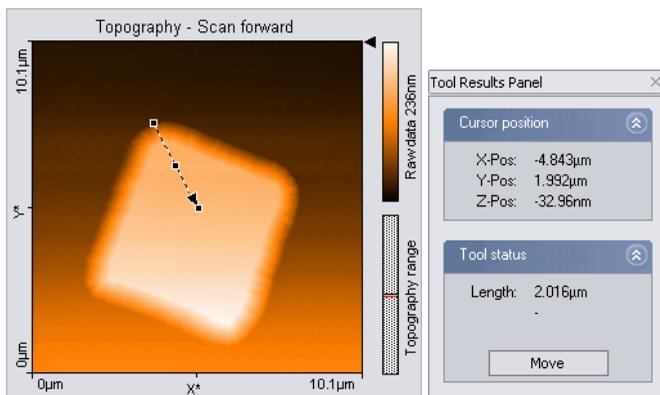
One corner of the zoomed area is defined by the mouse cursor position where the left mouse button is clicked, the opposite corner by the position where the button is released. When the mouse is not moved between clicking and releasing, an area is defined that has a size of 33% of the current measurement, and centred on the clicked location. Once an area is defined,

it can be resized by dragging one of its corners, and moved to the desired position by dragging its centre point.

A double click with the left mouse button in the chart, or clicking the Zoom button in the Tool Results panel, modifies the parameters Scan range, X-, Y-Offset in the Imaging window accordingly. When the zoom function is active it can be aborted by clicking  Full again.

 Move

Moves the position of the imaged area. An interesting corner can thus be moved to the centre of the measurement. The Tool Results panel numerically displays the change in position.



The change in the position is indicated by an arrow. The start of the arrow is defined by the mouse cursor position where the left mouse button is clicked, the end of the arrow by the position where the button is released. When the mouse is not moved between clicking and releasing, an arrow ending in the centre of the measurement is drawn. The direction of the arrow can be adjusted by dragging its end markers, it can be moved by dragging the centre marker.

The image is moved by double clicking, or clicking the Move button in the Tool Results panel. The move function can be aborted by clicking  Move again.

 Full

Returns the parameters Scan range to the largest possible values, and 'X-

Offset' and 'Y-Offset' to zero.

 Spec

Transfers the current measurement data to the spectroscopy window. If a measurement is in progress, it is interrupted. It is advisable to use  Finish to complete the current measurement before starting the spectroscopy measurement.

 Photo

Captures the measurement currently displayed in the 'Imaging window' in a measurement document.

If  Photo is clicked when a scan is in progress, a new measurement document is generated each time a measurement is finished. The capture process is cancelled by clicking  Photo a second time.

To capture an image without waiting for the scan to be completed, stop the scanning by clicking  Stop. The image can then be captured immediately by clicking  Photo.

The measurement documents are labelled automatically with increasing numbers (i.e. Image1, Image2,...). When leaving the program you will be asked if you want to save the unsaved measurement documents.

The Imaging panel

The imaging settings use two coordinate systems: The Scanner coordinate system and the Measurement image coordinate system. To separate the two systems, the image axes are denoted by an asterisk (i.e. X^* , Y^*). The relation between the two coordinate systems is determined by various parameters in the imaging panel. The effect of these parameters is illustrated in figure [Coordinate systems](#).

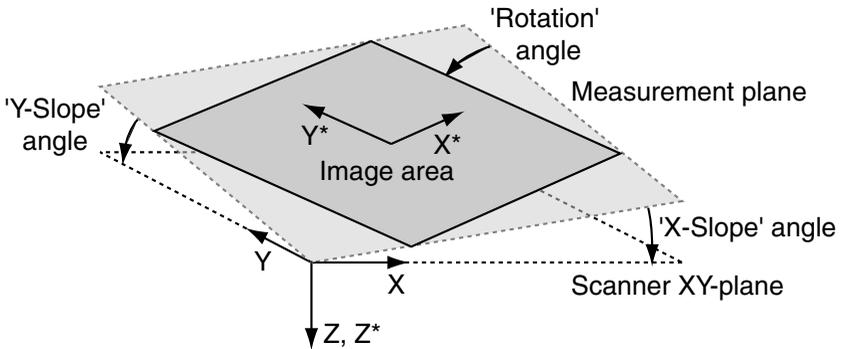
Imaging Area (Easy, Standard, Advanced)

Image size (Easy, Standard)

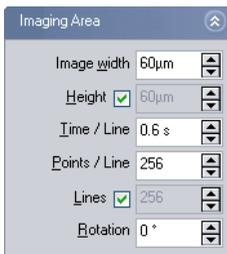
The image size in both the X^* and Y^* direction. The size is doubled or halved when using .

Image width (Advanced)

The image size in X^* direction.



Coordinate systems



Height (Advanced)

The image size in Y^* direction. When the Check-box is active, the image Height is always identical to the Image width.

Points / Line (Easy, Standard, Advanced)

The number of measured data points per line.

Lines (Advanced)

The number of measured data lines in an image. When the Check-box is active, the number of Lines is always equal to the number of Points / Line. In the easy and standard user interface mode, the number of Lines is always equal to the number of Points / Line.

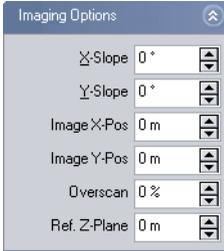
Time / Line (Easy, Standard, Advanced)

The time needed to acquire a data line. The time needed for the entire image is approximately:

$$\text{Image time} = \text{'Time / Line'} \cdot \text{'Lines / Frame'} \cdot 2$$

Rotation (Easy, Standard, Advanced)

The angle between the X-direction of the scanner and the X* direction of the measurement (figure *Coordinate systems*).

Imaging Options (Standard, Advanced)

The reference plane for the image can be aligned to the surface of the sample using the slope parameters (figure *Coordinate systems*).

X-Slope (Standard, Advanced)

A positive value rotates the image plane around the Y-axis in the counter-clockwise direction.

Y-Slope (Standard, Advanced)

A positive value rotates the image plane around the X-axis in the counter-clockwise direction.

The centre position of the measured area can be changed by typing its position as well as by using the Move tool in the imaging bar. The zero position is the centre position of the scanner.

Image X-Pos, Y-Pos (Advanced)

The centre position of the measured area.

Overscan (Standard, Advanced)

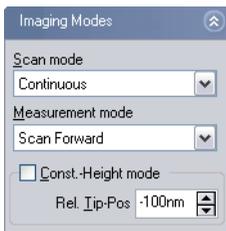
The amount by which the scan range of each line is made larger than the measurement range, relative to the image width. Thus edge effects, caused by the reversal of the scanning motion, are not displayed in the measurement. Disadvantages of using Overscan are that the maximum scan range is reduced, the tip moves slightly faster over the sample with the same 'Time/Line' setting, and the tip may hit large features outside the measured image. The value of 'Overscan' determines how much the scan range is

increased relative to the Image width.

Ref. Z-Plane (Advanced)

The height of the reference plane. This height reference is used when the Z-Controller output is cleared, and when the Z-position is not modulated relative to the current surface position during spectroscopy measurements.

Imaging Modes (Advanced)



Scan mode

The Y* direction in which the data is acquired and displayed:

Continuous the acquisition direction is reversed after each scan:
from bottom to top and vice versa

Cont.Up from bottom to top

Cont.Down from top to bottom

Measurement mode

The X* direction in which the data is acquired and stored:

Forward during forward scan only (left to right in the image)

Backward during backward scan only (right to left in the image)

Forw.&Backw. during both forward and backward scan

Const.-Height mode

When the Constant Height Imaging mode is enabled, the Z-Controller is turned off during the scan (as a consequence, the Sensor Status light will blink green). Instead, the scanner scans along a straight line, that should be parallel to the surface. The slope of the line is defined by the X- and Y-Slope parameters in the Imaging Options section of the Imaging Panel. These parameters should be set as described in section *Adjusting the measurement*

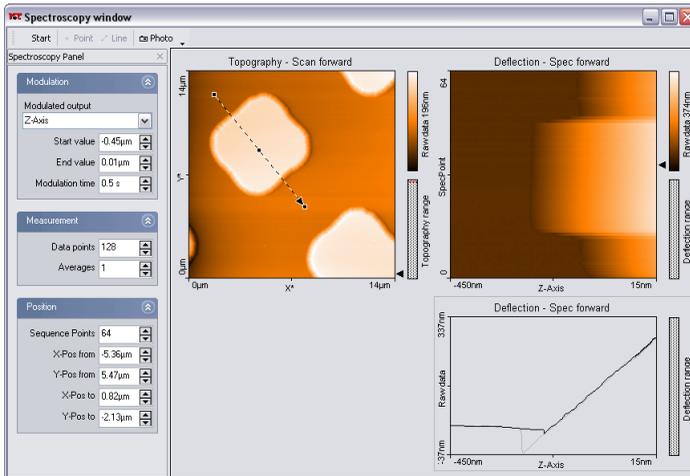
plane (p.54). The height of the line is determined at the start of each scan line: First the Z-Controller is turned on. Once the tip position is stable, the Z-Controller is turned off and the tip is moved away from the sample by the distance set by the parameter Rel. Tip-Pos.

The Constant Height Imaging mode is mainly useful for EFM and MFM measurements. For more information on how to do Magnetic Force Microscopy, refer to technical note *TN00031 Magnetic Force Microscopy*, which can be downloaded from the support section of the Nanosurf web site at www.nanosurf.com.

Rel. Tip-Pos

The distance by which the Tip is moved towards the sample from the position that corresponds to the set point. A negative setting will move the tip away from the sample.

Spectroscopy



Spectroscopy window

In a spectroscopic measurement, the input channels are measured as a function of a modulated parameter. This modulated parameter can be the Z-distance to the sample, the tip voltage, or a User output channel (when the Signal Module: A is installed). Note that you must electrically connect the sample to the ground connector on the easyScan 2 AFM scan head to apply a tip-sample voltage difference. The measured parameter can be any available input channel. Examples of a spectroscopic measurements are force/distance curves in the AFM static force mode, amplitude/voltage curves in the AFM dynamic mode, or current/voltage curves with the STM. The accuracy of the spectroscopic measurements can be increased by averaging the measurement results of several consecutive modulations. A spectroscopic measurement sequence consists of a number of spectroscopic measurements of the same type, measured along a user defined line in the XY-plane. A point measurement is made if the number of points is one. The measurement sequence is carried out as follows:

1. The tip is moved with active Z-control to the start of the line.
2. The Z-Controller is switched off.

3. A spectroscopic measurement is recorded.
4. The Z-Controller is turned on again.
5. The tip is moved to the next point on the line in the XY-plane.

Steps 2.-5. are repeated for each points on the line.

Spectroscopic measurement sequences are controlled using the Spectroscopy window. The Spectroscopy window can either be opened by clicking



in the navigator, or by clicking **Spec** in the Imaging bar. When the Spectroscopy window is activated from the Imaging bar, the currently measured image is transferred to the Spectroscopy window.

The Spectroscopy window contains the Spectroscopy bar, with commands that control the spectroscopy processes, and the Spectroscopy panel, with parameters that determine how the spectroscopy measurement is done.

The Spectroscopy window also contains a number of charts that display the data from a previous imaging measurement and the data from the ongoing spectroscopic measurement. The Spectroscopy window can display as many charts as the size of the window can accommodate. It is recommended to display at least two charts, one a Color map of a previous Topography measurement of the area where the spectroscopy measurement is performed, and one a Dual Line graph of the current spectroscopy measurement. For more information on adding and changing charts (chapter [Viewing measurement data](#) (p.134)).

The Spectroscopy bar

Start / Stop

Start starts a spectroscopy measurement sequence and then changes to **Stop** until the measurement sequence is finished. Clicking **Stop** aborts the measurement sequence as soon as the current modulation period is finished.

+ Point / Line

Starts the selection of the XY measurement position(s) in a topography Color map chart using the mouse cursor. These positions are automatically transferred to the appropriate entries in the Position section of the Spectros-

copy panel. When selecting a line, clicking the chart once creates a line from the clicked position to the centre of the image.

 Photo

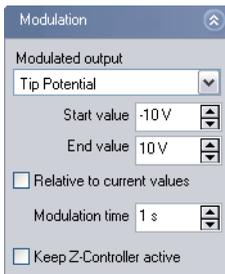
Captures the measurement currently displayed in the Spectroscopy window in a measurement document, and displays it in a separate window.

If  Photo is clicked during the measurement, a copy is generated when the measurement in progress is finished. During the measurement, the button remains pressed. The capture process is cancelled by clicking  Photo a second time.

The measurement documents are labelled automatically with increasing numbers (i.e. Image1, Image2,...). When leaving the program you will be asked if you want to save the unsaved measurement documents.

The Spectroscopy panel

Modulation (Easy, Standard, Advanced)



Modulated output (Easy, Standard, Advanced)

The number of available modulated outputs depends on the scan head and the number of installed modules operating modes that are available. Possible values are: 'Z-Axis', 'Tip Potential' and the names of the User Outputs.

Start value/End value (Easy, Standard, Advanced)

The range over which the Modulated output is changed. The 'Spec Forward' data is measured from the Start to the End value, the 'Spec backward' data is measured in the opposite direction. The 'Spec forward' data is always measured before the 'Spec backward' data.

Relative to current value (Standard, Advanced)

When active, the Start and the End values are added to the value the modulated output had before starting the modulation.

When the Tip Potential is modulated, the current value is the Tip voltage set in the Z-Controller panel.

When the Z-Axis is modulated, the current value is the sample surface height, as measured using the Z-Controller output. Otherwise, the measurement z-position is given by the value of the Ref. Z-Plane in the Imaging Panel.

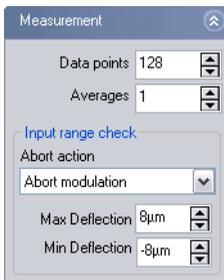
Modulation time (Easy, Standard, Advanced)

The time used to change the Modulated output from the Start to the End value.

Keep Z-Controller active (Advanced)

The Z-Controller will continue to change the Z-position so as to keep tip-sample interaction constant. This option is not available when the Modulated output is set to the Z-Axis.

This setting can for example be used to measure tip current as a function of applied voltage whilst keeping the tip-sample force constant.

Measurement (Easy, Standard, Advanced)**Data points (Easy, Standard, Advanced)**

The number of data points in one spectroscopic measurement. The data points are equally distributed over the modulation range.

Averages (Easy, Standard, Advanced)

The number of times the modulation is repeated to obtain an averaged spectroscopic measurement. The measurement results of aborted modula-

tions are discarded during averaging.

Input range check (Standard, Advanced)

In order to prevent tip damage due to too high tip-sample interaction, the settings below 'Input range check' define a safe range of tip-sample interaction. When the interaction signal (Deflection in static modes, Amplitude in dynamic modes, Current in STM mode) leaves this safe range, the measurement is aborted. When a spectroscopy measurement has been aborted, a warning dialog is displayed. The number of aborts that occurred in a measurement is reported in Data Info panel as: ModAborted=<number of aborts>.

Abort action (Standard, Advanced)

What is to be done when the measurement is aborted:

No range check will never abort the measurement. The tip is not protected against damage due to too high tip-sample interaction. This is the default setting.

Abort modulation aborts the current modulation period, and continues with the next modulation until the number of modulations in 'Averages' is reached.

Abort current measurement aborts the spectroscopy measurement for the current point and continues with the next point of the line, if a Line spectroscopy is being performed.

Abort measurement sequence aborts the entire spectroscopy measurement sequence (cancels all 'Averages' and points).

Max / Min input value (Standard, Advanced)

The Minimum/maximum value that the feedback signal is allowed to have.

Position (Easy, Standard, Advanced)

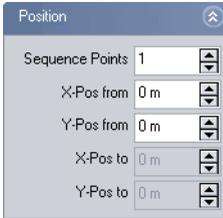
The Position parameters can be used to define a sequence of spectroscopy measurements on positions that are equally distributed over a line.

Sequence Points (Easy, Standard, Advanced)

The number of Spectroscopy Measurements to be made in the sequence.

X-Pos from/Y-Pos from (Easy, Standard, Advanced)

The XY-coordinates of the measured point in a Point -spectroscopy measure-



ment. Sets the XY-coordinates of the starting point of the line in a -spectroscopy measurement sequence.

X-Pos to Y-Pos to (Easy, Standard, Advanced)

The XY-coordinates of the end-point of the line in a -spectroscopy measurement sequence.

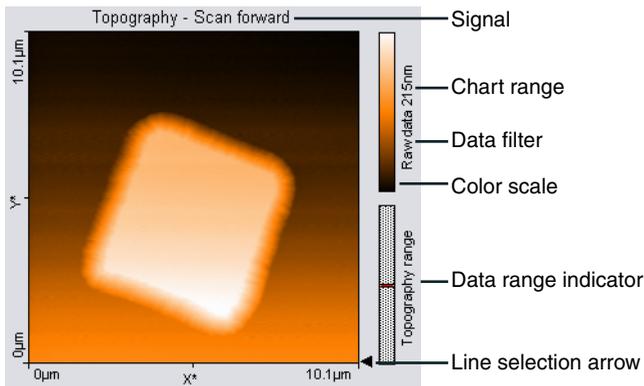
The from and to coordinates are more conveniently chosen using the  or  tools in the Spectroscopy bar.

Viewing measurement data

Measurement data are displayed in charts. Charts are used in Measurement document windows, the Imaging window and the Spectroscopy window. The measurement settings are displayed in the Data Info panel.

Charts

A Chart is a graphical representation of the measured data, and additional elements that give information about the chart itself (figure *Elements of a Chart*).



Elements of a Chart

These elements show the displayed Signal, Chart type, the type of Filtering applied to the data, and the Color scale used to display the data. The Color scale shows which measured signal level is mapped to which colour. The colour mapping can be changed using the Color Palette dialog, described further on in this section. The Data range indicator shows the range of possible measurement values that is occupied by the measured data.

The Chart bar is used to create new charts and to modify their properties. The chart configuration of the Imaging and Spectroscopy window can be saved to a file. The chart configuration of the measurement documents is saved together with the document.

Storing and retrieving the chart arrangement

The chart arrangement of the Imaging and Spectroscopy windows is stored in a configuration file with the extension '.chart'. When the easyScan 2 software is started, a default arrangement is loaded from a file that is selected in the Controller Configuration dialog (section *The Controller Configuration dialog* (p.110)). Functions for storing and retrieving the chart arrangement are accessed via the menu 'File>Chart Arrangement'.

'Save' saves the chart arrangement to the currently selected chart file. The name of this file is indicated in the status bar at the bottom of the main window.

'Save as...', saves the chart arrangement under a new file name.

'Load' loads a previously saved chart file.

IMPORTANT

When you have not loaded another file, 'Save', will overwrite the original default chart arrangement file with the current settings.

The Chart bar

The properties of the charts are set using the Chart bar. The settings displayed in the Chart bar refer to the currently active chart. This chart is indicated by a grey line around the chart. A Chart is activated by clicking it with the mouse cursor.

The following buttons control the creation and modification of the charts.

 (Create new Chart)

Creates a copy of the currently active chart and adds it as the last chart in the active window. Charts are first ordered top to bottom, then left to right. The window may have to be resized to see all charts.

 (Delete Current Chart)

Removes the currently active chart.

 (Chart type)

The chart type:

Line graph data is displayed as a plot. Points outside the range of

the scanner are displayed in red. The displayed line is selected by dragging the Line selection arrow in a Color map or Shaded map chart (figure *Elements of a Chart* (p.134)).

Color map

data is encoded in a color scale

3D view

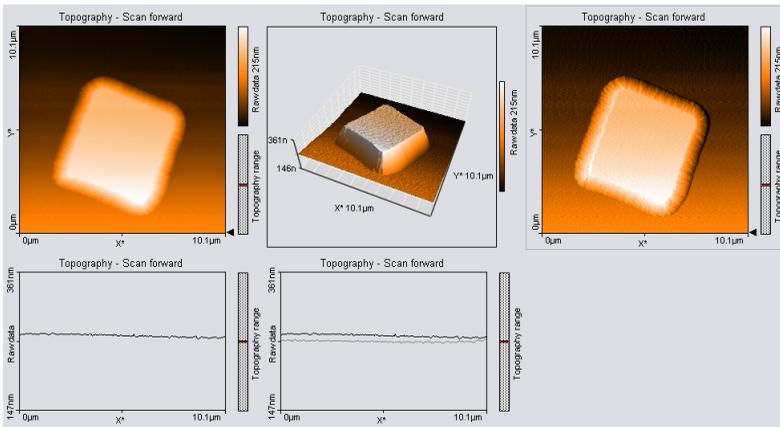
data is shown as a 3-dimensional representation in a parallel perspective, see *Changing the appearance of the 3D view* (p.138)

Shaded map

creates an impression of the surface with lighting from the left. This is achieved by combining the topography with its derivative.

Dual line graph

both the Forward and the Backward data (when available) are displayed as in the ‘Line graph’. The line of the data type selected in ‘Signal’ is black, the line of the reverse direction data is grey.



Data represented using different chart types

🔍 (Data filter)

The way data is processed before it is displayed, evaluated or exported:

Raw data

the data is not processed.

Mean fit	the mean value of each line of data points is calculated and then subtracted.
Line fit	the best fit line for each line of data points is calculated and then subtracted.
Derived data	the difference between two successive data points (derivative) is calculated.
Parabola fit	the best fit parabola for each line of data points is calculated and then subtracted.
Polynomial fit	the best fit fourth order polynomial for each line of data points is calculated and then subtracted.

(Signal)

The input channel that is displayed. The available signals depend on the operating mode, the status of the User input (section *The Operating mode panel* (p.95)) and the measurement mode (section *The Imaging panel* (p.123)).

(Optimise Chart range)

Adjust the chart scale so that it optimally fits the measurement data.

(Decrease Chart range)

Halves the chart scale, thereby increasing feature contrast / height.

(Increase Chart range)

Doubles the chart scale, thereby decreasing feature contrast / height.

(Chart properties dialog)

Opens the chart properties dialog.

The Chart properties dialog

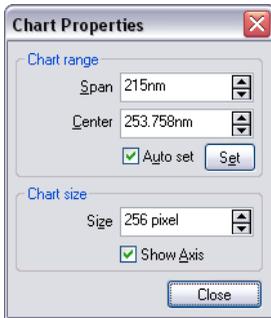
Chart range

Span

The signal span that corresponds to the full chart scale. Increasing Span decreases the feature contrast. The current Span is also displayed next to the color bar / axis in the chart

Center

The signal that corresponds to the center of the chart scale.



Auto set

When active, the chart scale is automatically set to optimally fit the measurement data, as it is being acquired. Clicking  has the same effect as clicking the Optimise Chart range button.

Chart size

Size

The size of the chart in pixels.

Show Axis

When active, the labels in charts and the color-bar in 'Color map' window, are displayed.

Changing the appearance of the 3D view

Always click and hold the left mouse button on the 3D view chart while changing the 3D view. The surface is reduced in feature complexity as long as the left mouse button is pressed. Press the following additional keys/buttons to determine what chart property is changed:

Surface rotation mouse left/right

Surface tilt mouse up/down.

Size displayed surface 'Ctrl'-key + mouse up/down

Surface position 'Shift'-key + mouse up/down/left/right

Z-scale magnification left mouse button + right mouse button + mouse up/down

Light source direction (360°) 'Shift' + 'Ctrl'-key + mouse left/right

Light source height (0°-90°) ‘Shift’ + ‘Ctrl’-key + mouse up/down

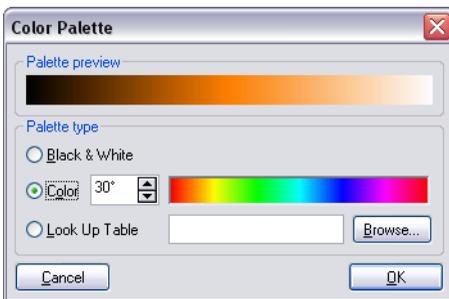
The lowest height of 0° corresponds to ‘sunset’ lighting, the highest height corresponds to mid-day lighting at the equator.

The Chart Properties “Span” and “Center” can be used to cut off high and or low features of the surface.

Tip

To create good-looking 3D images you can use any of the following features:

- Use the Tools ‘Correct Scan Line Level’, ‘Glitch’ and ‘Noise reduction’ filters to remove unwanted measurement artefacts.
- Set the light source direction to 90° (parallel to the scan lines)
- Click  once or twice until no clipping of high features is visible (or adjust the “Span” and “Center” Properties).

The Color Palette dialog

The color palette dialog is reached via the menu item ‘Options>Config Color palette...’. The color palette is used to map the display range of the measured values to a color. Three different palette types are available:

Black&White The color map is a linear grey scale

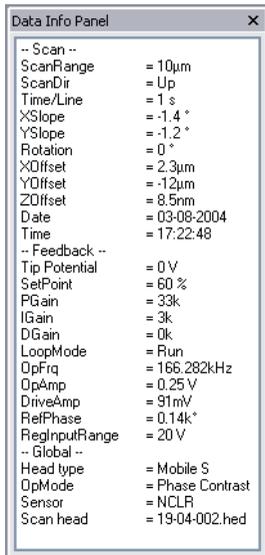
Color The color selection uses the HSB-color model where the color (H) is set in ° value. The color is selected by

entering a number or by clicking a color in the color bar.

Look Up Table

A user definable palette (with max. 256 color entries) can be selected. This palette is stored in a '.lut' file that contains an ASCII table with RGB color values. A different look up table can be selected by clicking the 'Browse...' button.

The Data Info panel



Data Info Panel: Display of measurement parameters

The Data Info panel displays the parameters of the active measurement and the current tool results.

Quick Evaluation Tools

The easyScan 2 software has several tools that allow quick evaluation of a measurement while it is being acquired. This helps find optimal measurement settings. For more elaborate evaluations, the optional Nanosurf Analysis or the Nanosurf Report software package can be used (section *Creating a report* (p.153)).

The quick evaluation tools are activated using the Tools bar or the Tools menu. The number of tools available depends on the type of the currently active chart. The evaluation results are displayed in the Tool Results panel.

IMPORTANT

All results are calculated after the 'Data filter' has been applied to the data. The results will generally vary when a different 'Data filter' option is used.

The Tool Results panel

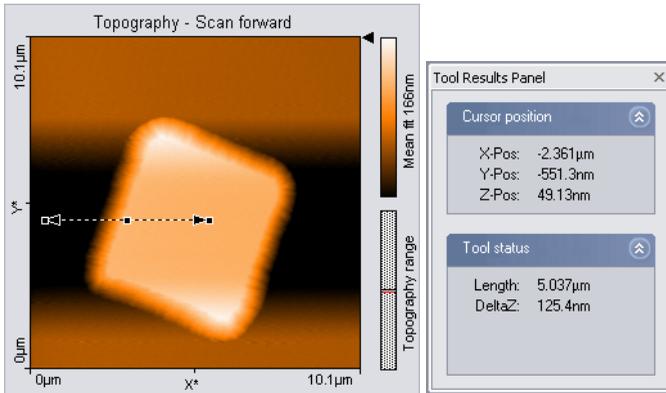
The Tool Results panel displays the results of the currently active tool. The panel should automatically become visible when a tool is selected. To make the panel visible, click  in the navigator. The contents of the tool results panel depend on the tool that is active. It will always contain a Cursor position and a Tool status section, and may also contain a Tool result and a Tool chart section. Because the content of the Tool Results panel depends so strongly on the active tool, this panel is described in more detail with each of the tools.

The Tools bar

Properties of the measurements can be evaluated numerically using the tools. The tools are activated via the corresponding menu item or by clicking the respective button in the tool bar. Tools can be used in all charts, both during measurement and off-line. Before using a tool on a chart, activate the chart by clicking onto it. To stop using a tool, select another tool, or click its button a second time.

Measure Length

Starts measuring the distance and signal difference between two points. The measurement results are displayed in the Tool Results panel.



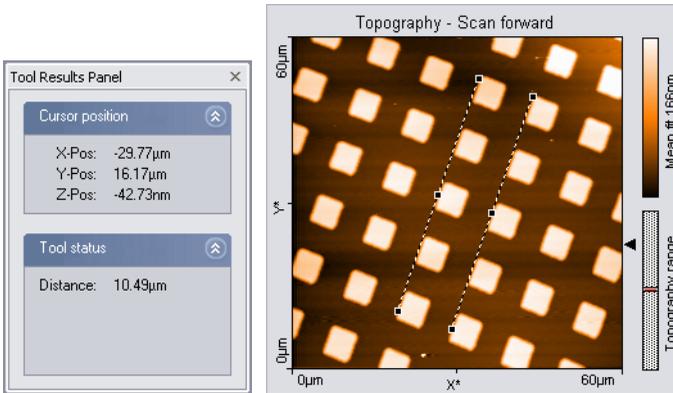
The two points are defined by drawing a double arrow. The first point is defined by the mouse cursor position where the left mouse button is clicked, the second point by the position where the button is released. When the mouse is not moved between clicking and releasing, an arrow parallel to the X^* -axis is drawn.

The direction of the arrow can be adjusted by dragging its end markers; it can be moved by dragging the centre marker.

Measure Distance

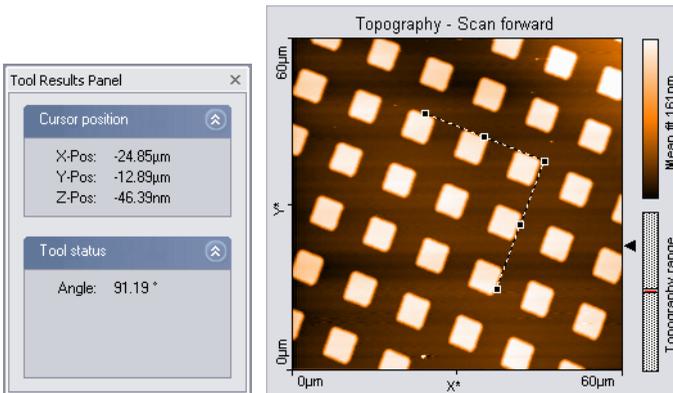
Starts measuring the distance between two parallel lines. The measurement result is displayed in the Tool Results panel.

Distance is measured by drawing two lines in the chart. The first point of the first line is defined by the mouse cursor position where the left mouse button is clicked, the second point by the position where the button is released. When the mouse is not moved between clicking and releasing, a line parallel to the X^* -axis is drawn. After releasing the mouse button, a second parallel line sticks to the mouse cursor, that is released by clicking its desired position. The direction of the parallel lines can be adjusted by dragging their end markers; they can be moved by dragging the centre marker.



Measure Angle

Starts measuring the angle between features in the measurement. The measurement result is displayed in the Tool Results panel. In Line graph-type displays, this tool can only be used when the signal displays height data.

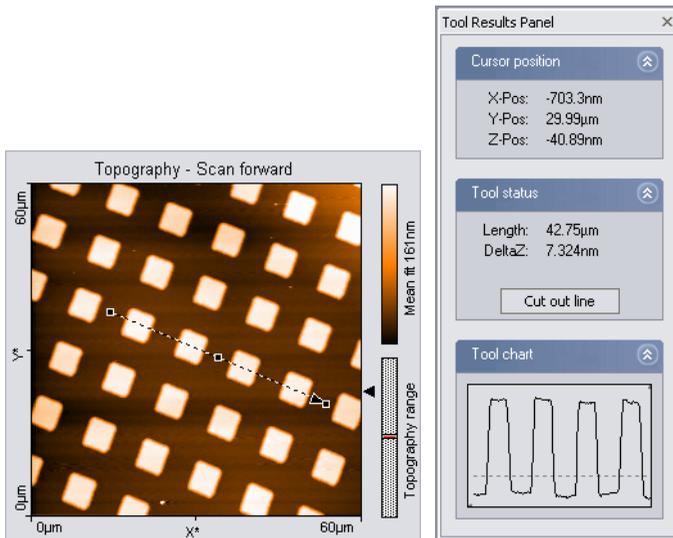


The angle is measured by drawing two meeting lines in the chart. The first point of the first line is defined by the mouse cursor position where the left mouse button is clicked, the second point by the position where the button is released. When the mouse is not moved between clicking and releasing, a line parallel to the X*-axis is drawn. After releasing the mouse button, the end of the second line sticks to the mouse pointer. The end is released by clicking its desired position. The angle can be changed by dragging the

line's end point markers or the corner mark; it can be moved by dragging the line's centre markers.

 **Create Cross Section**

Displays and can create a new measurement document containing a line cross-section of a Color map or Line View display. The line is displayed in the Tool Results panel. The line can be stored in a new measurement document.

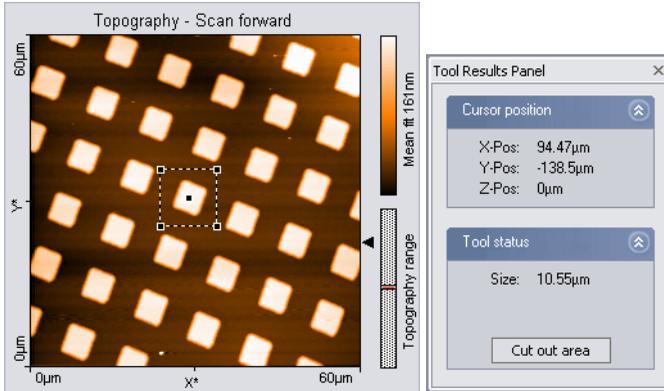


The line is defined by drawing an arrow. The arrow points toward the forward direction of the line. The start of the arrow is defined by the mouse cursor position where the left mouse button is clicked, the end of the arrow by the position where the button is released. When the mouse is not moved between clicking and releasing, an arrow ending in the centre of the measurement is drawn. The direction of the arrow can be adjusted by dragging its end markers; it can be moved by dragging the centre marker.

A new measurement document containing the line section is created by double clicking the graph, or by clicking 'Cut out line' in the Tool Results panel.

Cut Out Area

Creates a new measurement document containing a subsection of an existing measurement. The size and area of the area is displayed in the Tool Results panel.



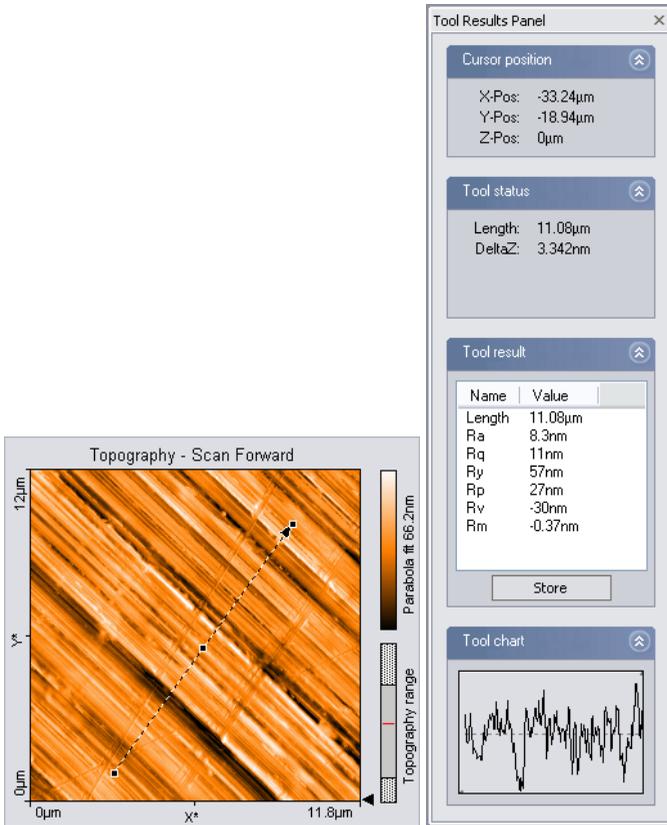
One corner of the area is defined by the mouse cursor position where the left mouse button is clicked, the opposite corner by the position where the button is released. When the mouse is not moved between clicking and releasing, an area is defined that has a size of 33% of the current measurement, and is centred on the clicked location. Once an area is defined, it can be resized by dragging one of its corners, and moved to the desired position by dragging its centre point. It is possible to define a rectangular (i.e. non-square) area by pressing the 'Shift' key whilst dragging a corner.

A new measurement document containing the area is created by double clicking the graph, or by clicking the 'Cut out area' button in the Tool Results panel.

Calculate Line Roughness

Calculates certain roughness parameters along a line. Both the selected line and calculated values are displayed in the Tool Results panel.

The cross-section is selected in the same way as with the Cut out Line tool. The calculated parameters are stored in the measurement document when the 'Store' button in the Tool Results panel is clicked.



Ra Calculate Area Roughness

Calculates certain roughness parameters of an area. The calculated values are displayed in the Tool Results panel.

The parameters are calculated as follows:

The Roughness Average, S_a

$$S_a = \frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} |z(x_k, y_l)|$$

The Mean Value, S_m

$$S_m = \frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} z(x_k, y_l)$$

The Root Mean Square, S_q

$$S_q = \sqrt{\frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} (z(x_k, y_l))^2}$$

The Valley depth, S_v

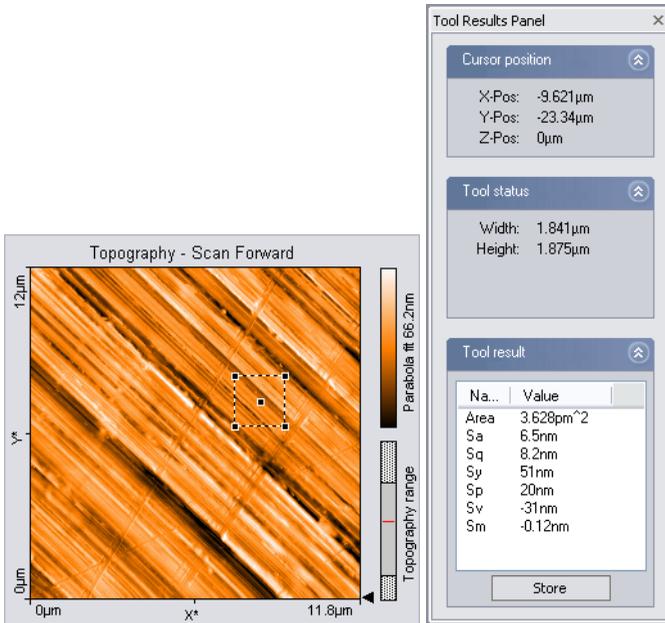
$$S_v = \text{lowest value}$$

The Peak Height, S_p

$$S_p = \text{highest value}$$

The Peak-Valley Height, S_y

$$S_y = S_p - S_v$$



The area is selected in the same way as with the Cut out Area tool. The calculated parameters are stored in the measurement document when the 'Store' button in the Tool Results panel is clicked.

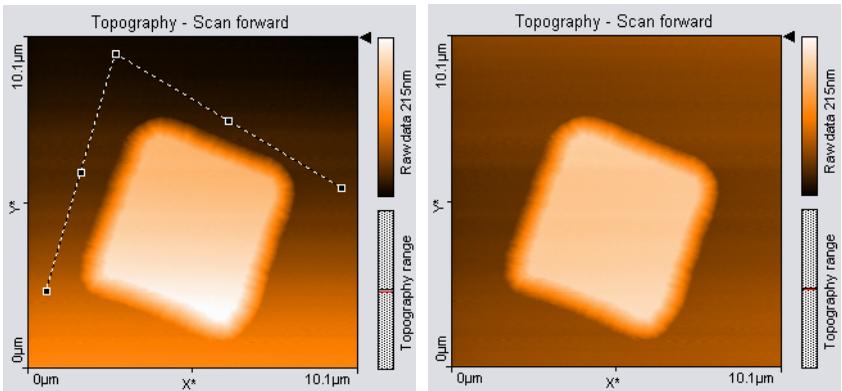
Tip

The Area Roughness tool can be used to determine the mean height difference between two plateaus with more accuracy than with the 'Measure Distance' tool. To determine the mean height difference, select an area on each plateau, and calculate the difference between their Sm-values.

Correct Background

Removes the effect of a wrong scan plane when the 'average' and 'plane' Data filter options do not give satisfactory results. This may occur when the scan lines in different parts of the measurement have a different average height. An example of such a measurement is shown in figure [Correct Background](#).

To use the tool, select three points that should be on the same height. This



Correct Background: left: uncorrected image, the end points of the lines have been moved to points that should have the same height; right: corrected image

is done with in the same way as the angle tool. The selected points are the end points of the two connected lines.

After clicking the ‘Execute’ button in the Tool Results Panel, the plane that is defined by the three points is subtracted from the measurement. To get useful results, the Data filter option for the display in which you draw the line should generally be ‘Raw data’.

Correct scan line levels

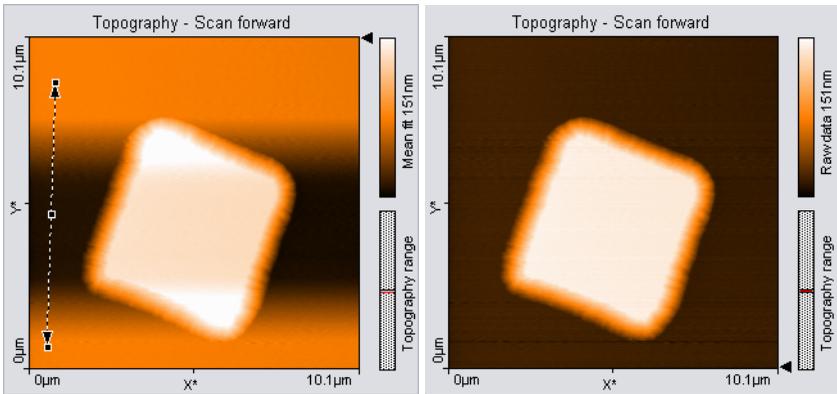
Removes the effect of drift when the ‘average’ and ‘plane’ Data filter options do not give satisfactory results. This may occur when the scan lines in different parts of the measurement have a different average height. An example of such a measurement is shown in figure [Correct scan line levels](#).

To use the tool, draw a line through points that should have the same height in the same way as with the Measure Length tool.

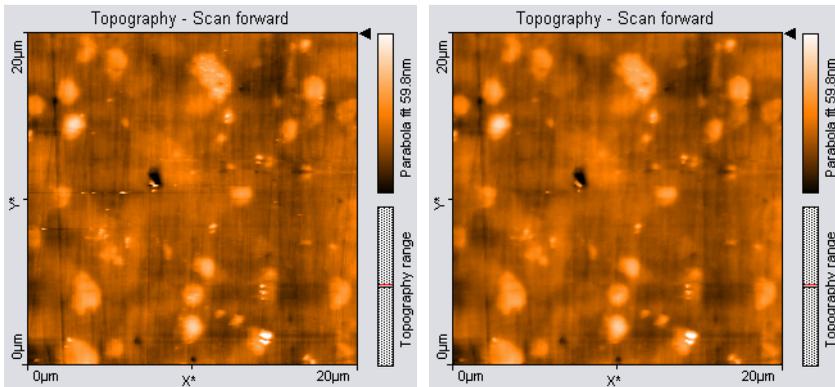
After clicking the ‘Execute’ button in the Tool Results Panel, the average level of each scan line is adjusted so that all points along the drawn line have the same height. To get useful results, the Data filter option for the display in which you draw the line should generally be ‘Raw data’ or ‘Mean fit’.

Glitch Filter

The Glitch Filter removes the effect of small defects in the image such as single short glitches in the scan. Compared to the Noise Filter, it has the advantage of not reducing resolution on step edges. The glitch filter is



Correct scan line levels: left: uncorrected image with a line through points that should be at the same height; right: corrected image



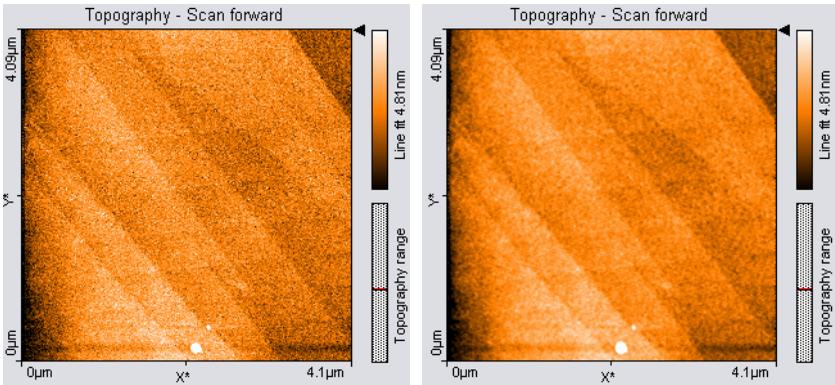
Glitch Filter: left: unfiltered image with some glitches where the tip lost contact with the sample; right: corrected image

implemented as a Median filter on a 3x3 pixel matrix.

To apply the filter, activate the color map chart that is to be filtered, then click the Glitch Filter button in the Tools bar. A new Measurement document with the filtered data is created.

Noise Filter

The Noise filter removes high frequency noise from the image, but applying the filter will also decrease the resolution of the image. The Noise Filter is



Noise Filter: left: unfiltered image of AFM measurement on HOPG; right: filtered image

implemented as a convolution with a 3x3 pixel Gaussian kernel function. To apply the filter, activate the color map chart that is to be filtered, then click the Noise Filter button in the Tools bar. A new measurement document with the filtered data is created.

Tip

Filters are especially useful for improving the appearance of 3D views. Applying filters may change the result of the other tools. This may result in incorrect results when evaluating sample roughness.

Storing measurements and further data processing

Storing and Printing measurements

Storing and Printing of measurement documents can be performed using the File menu. The functions Open, Save and Print are also available via the File bar.

Menu item 'File' contains the items for opening , closing, saving , and printing  the measurement documents and for exiting the program. In the following only the special functions are mentioned.

Open

Opens a dialog for opening Nanosurf '.nid' or '.ezd' (easyScan 1) files. The same dialog is opened using the menu 'File>Open...'. It is possible to select more than one file at the same time by using the 'Shift' and 'Ctrl' keys.

'Save' and 'Save as...'

Save a measurement document in Nanosurf image data format (file extension '.nid'). The same dialog is opened using the menu 'File>Save' and 'File>Save as...'.

Export >Current Chart as / Current document as

Exports either the active chart or the whole active measurement document for use in other programs or image processing software. Available data types for documents are windows bitmap (.bmp), 16 bit data file (.dat), plot file (.plt). For Charts, additional available data types are comma separated z values (.csv), and (X,Y,Z)-points (.csv).

When the data is exported using the function 'Export>Current document as...', every Chart in the measurement document is stored in the export file consecutively. In the binary format, the blocks of data from each Chart are stored directly one behind the other. In the 'ASCII' text format the blocks of data for each Chart are separated by two empty lines.

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 16Bit (.dat)

A 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 16-bit values (-32768 - +32767). The data is first processed using the settings chosen in the Data filter setting of the Chart bar.

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 'Data filter' in the 'Chart bar'. A measurement as a plotfile can be used for detailed data analysis by various mathematical software packages such as MathLab or plotted by GnuPlot.

- If 'Line graph' is selected as 'Display' in the 'Chart bar', only the visualised 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 any other chart type is selected, all measured values are stored. All values in a data line are stored on a separate line in the text file. 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 with their physical units.

Comma separated z values (.csv)

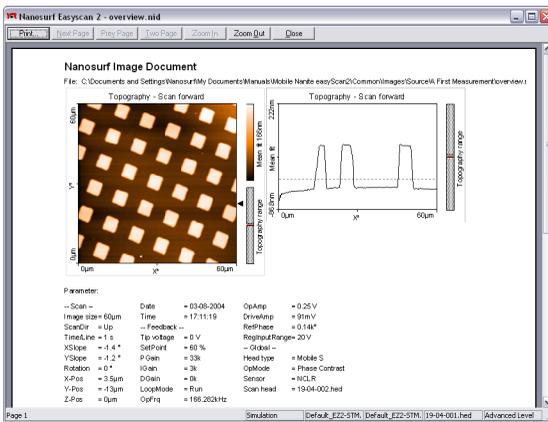
This format stores all the measured data in a chart, as a matrix of floating point numbers in ASCII format separated by a 'comma' and 'SPACE' character. This enables easy data exchange with commonly used spread sheet and database applications.

(X, Y, Z)-Points (.csv)

This format stores the coordinates of all measured points in a chart as a list of floating point number pairs. For Line graphs, only X and Z points are exported.

Print, Print preview...

Prints the currently selected measurement document together with the values shown in the Data Info panel.



Creating a report

The Nanosurf Report software package offers a powerful and extensive set of analysis functions. Complex analyses can be created interactively, and then displayed and printed in visually appealing reports. These reports can then be used as templates to apply the same analysis to another measurement.

The Report software is started from the easyScan 2 software by either clicking , or using the Report menu. When a measurement is opened by the report software, it will import all measurement channels that are displayed in the current measurement document.

IMPORTANT

- After a fresh installation of the Report software, the Report software has to have run at least one time before you can automatically start it from the easyScan 2 software. To run the Report software for the first time, select it from the MS Windows 'Start' menu.
 - If you do not save the measurement in the easyScan 2 software, but only save the report, the data in measurement channels that were not displayed is lost.
 - A measurement document should only display those channels that are used in a template. When a template is applied to a measurement document that displays different, or a different number of measurement channels than the template uses, the results may not be correct.
-

The Report generator configuration dialog is used to configure the behaviour of the Navigator Icon and the Report menu. For an in depth introduction to the Nanosurf Report software, refer to the Introduction section of the Nanosurf Report on-line help.

The Report Menu

New Report

An empty report is opened.

Add Measurement

The currently active measurement is added to the currently opened report.

Apply Template...

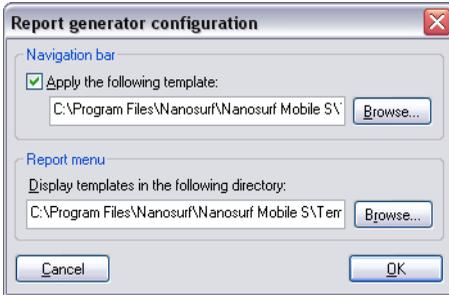
Opens a dialog that allows you to select a template that is applied to the currently active measurement.

Template list

The template list is a list of the templates that are stored in the template directory (section *The Report generator configuration dialog* (p.155)). Selecting a template applies this template to the currently active measurement.

The Report generator configuration dialog

The Report generator configuration dialog is used to configure the behaviour of the Navigator Icon and the Report menu. It is opened using the menu 'Options>Config Report...'.



Navigation bar

Determines what happens when the  icon is clicked. The check box determines whether the active measurement is evaluated using a template. The Browse-button is used to select the template that is used when the icon is clicked.

Report menu

Determines which templates are displayed in the lower part of the Report menu. The Browse-button allows the selection of the directory where the templates are stored.

Automating measurement tasks

The Nanosurf easyScan 2 AFM Scripting Interface is an optional component for automating measurement tasks. It offers several possibilities to automate measurement tasks:

- Create scripts inside the easyScan 2 software.
- Create external software that controls the easyScan 2 software.

This chapter describes the user interface features that are related to creating scripts inside the easyScan 2 software.

After purchasing it, the Scripting Interface must be activated using the Edit Access Codes dialog (section *The Edit Access Codes Dialog* (p.112), or follow the instructions on the Access code certificate delivered with the instrument.)

For more information about the automating measurement tasks, and the available script commands, refer to the *Programmers Manual*. This manual is available as an on-line help file, that can be opened via the windows Start menu: 'Start>Program files>Nanosurf>Nanosurf easyScan 2 AFM>easy-Scan 2 AFM Programmers Manual'.

The Script Menu

The scripting functions of the easyScan 2 software are reached via the entries in the Script menu:

Script Editor...

Opens the Script Editor dialog.

Run From File...

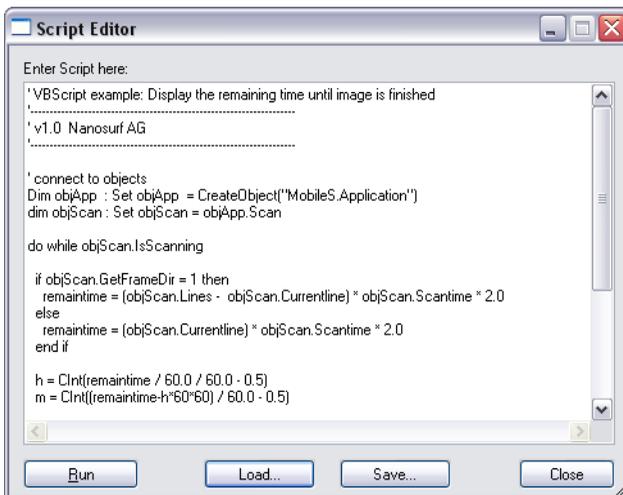
On selecting this menu entry, a file dialog appears that allows selecting a script file by browsing. When the script is error free, the script will start executing on clicking the 'Load'-button. Otherwise, and error message with an error description will appear.

Other entries

All scripts in the script directory are displayed below the Run From File menu entry. Selecting one of these entries starts the corresponding script. The example script 'Show Remain Scantime', which is installed in the default installation, should normally be listed here.

The Script Editor

The easyScan 2 software has an simple integrated Script Editor that allows editing, running, loading and saving scripts. The can be used in parallel with other application windows, so you can work with other parts of the application while editing a script. The Script Editor is accessed via the menu 'Script>Script Editor...'.
 The script editor window is shown in the following image.



The script editor

Editor field

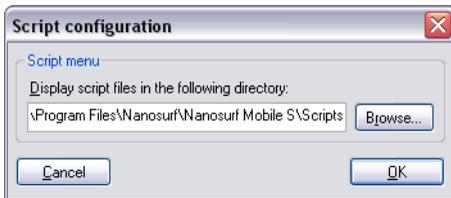
In the editor field in the center of the dialog you can edit scripts.

Run Button

Starts the currently loaded script. If there is an error in the script, a dialog box will appear.

The Script Configuration Dialog

The Script Configuration Dialog allows you to set the search path for the scripts that are displayed in the Script menu. The dialog is accessed via the menu entry 'Options>Config script...'.



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