



# Operating Instructions

## easyScan 2 STM

*Version 1.3*

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# Table of contents

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|  |           |
|--|-----------|
| <b>The easyScan 2 STM</b>                        | <b>7</b>  |
| Features.....                                    | 8         |
| easyScan 2 Controller                            | 8         |
| Components of the system .....                   | 10        |
| Contents of the Tool set                         | 12        |
| Connectors, Indicators and Controls .....        | 13        |
| The Scan head                                    | 13        |
| The Controller                                   | 13        |
| <b>Installing the easyScan 2 STM</b>             | <b>16</b> |
| Installing the Hardware .....                    | 16        |
| Installing the Basic STM Package                 | 17        |
| Installing the Signal Module: S                  | 17        |
| Installing the Signal Module: A                  | 17        |
| Turning on the Controller                        | 17        |
| Storing the Instrument .....                     | 18        |
| Installing the Software .....                    | 18        |
| Step 1 - Installation of hardware drivers        | 19        |
| Step 2 - Installation of the easyScan 2 software | 21        |
| Step 3 - Installation of DirectX 9               | 21        |
| Installing the software on different computers   | 22        |
| <b>Preparing for Measurement</b>                 | <b>23</b> |
| Initialising the Controller .....                | 23        |
| Preparing and installing the STM tip.....        | 23        |
| Installing the sample.....                       | 26        |
| Preparing the sample                             | 26        |
| Installing the sample                            | 27        |
| <b>First Measurements</b>                        | <b>29</b> |
| Running the microscope simulation.....           | 29        |
| Preparing the instrument .....                   | 30        |
| Entering values in the control panels            | 30        |
| Approaching the sample.....                      | 31        |
| 1. Manual Coarse approach                        | 32        |
| 2. Manual approach using the piezo motor         | 33        |
| 3. Automatic final approach                      | 33        |
| Starting a measurement .....                     | 35        |
| Achieving atomic resolution.....                 | 35        |
| The graphite surface.....                        | 37        |
| Storing the measurement .....                    | 38        |
| Finishing .....                                  | 39        |

|  |           |
|--|-----------|
| Measuring Gold .....                                     | 39        |
| Creating a report.....                                   | 41        |
| Turning off the instrument.....                          | 41        |
| <b>Improving measurement quality</b>                     | <b>42</b> |
| Judging and improving tip quality .....                  | 42        |
| Decreasing thermal drift.....                            | 44        |
| Removing interfering signals .....                       | 45        |
| Adjusting the measurement plane .....                    | 46        |
| <b>Measurement modes</b>                                 | <b>50</b> |
| <b>The Signal Modules</b>                                | <b>52</b> |
| Signal Module: S.....                                    | 52        |
| Signal Module: A.....                                    | 53        |
| Using the User Inputs and Outputs                        | 55        |
| <b>Maintenance</b>                                       | <b>56</b> |
| Scan head  | 56        |
| Cleaning parts of the approach motor                     | 56        |
| Scan electronics   | 57        |
| <b>Problems and Solutions</b>                            | <b>58</b> |
| Common problems .....                                    | 58        |
| No connection to microscope                              | 58        |
| USB Port error   | 58        |
| Manual approach is too slow / stops sometimes            | 59        |
| Automatic final approach is too slow / stops sometimes   | 59        |
| Automatic final approach crashes the tip into the sample | 59        |
| Image quality suddenly deteriorates                      | 60        |
| Nanosurf support .....                                   | 61        |
| Self help  | 61        |
| Assistance   | 61        |
| <b>STM Theory</b>  | <b>63</b> |
| What is STM? .....                                       | 63        |
| Scanning with the easyScan 2 STM .....                   | 64        |

### **About this Manual**

This manual gives instructions on how to set up and use your Nanosurf easyScan 2 STM system. *Installing the easyScan 2 STM* should be read when installing your easyScan 2 STM system. The chapters *Preparing for Measurement* and *First Measurements* should be read by all users, because they contain useful instructions for everyday measurements. The chapter *STM Theory* gives some general information on the scanning tunneling microscopy technique and its implementation in the easyScan 2 STM. The other chapters give more information for advanced or interested users. Those who need a more detailed description of the functions of the easyScan 2 software should refer to the *Software Reference* manual.

## The easyScan 2 STM

---

The Nanosurf easyScan 2 STM was designed to allow people without training as a physicist to do experiments in the world of atoms. Its design is compact, simple and comfortable to operate. With the easyScan 2 STM, it is possible to do any STM experiment which can be carried out in air. The sample approach system allows simple handling of samples and tips, whilst at the same time providing maximum stability of the tip-sample distance. All functions can be carried out using a computer and the easyScan 2 software.

The easyScan 2 STM 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 STM scan head, the Vibration Isolation Platform, the easyScan 2 Controller, and the easyScan 2 software. At the time of publication, the following parts can be used with the easyScan 2 system:

- AFM Scan Heads and modules used for AFM operation: can also make measurements on non-conducting samples. Refer to the *easyScan 2 AFM Operating Instructions* for more details.
- Signal Modules: allow monitoring signals (Module: S) and creating custom measurement modes (Module: A). Refer to chapter *The Signal Modules* (p.52) for more details.
- Nanosurf Report: software for detailed measurement analysis and automatic report generation.
- Scripting Interface: software for automating measurements. Refer to the *Software Reference* and *Programmers Reference* 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

|                                    |  |
|------------------------------------|--|
| Electronics size / weight          | 470 x 120 x 80mm / 2.4kg                                       |
| Power supply                       | 90 - 240V~/ 30W 50/60Hz  |
| Computer interface                 | USB 1.1  |
| Integrated USB hub                 | 2 Ports (100mA max)  |
| Measurement channels               | 16bit A/D converters, up to seven signals depending on mode.   |
| Scan generator                     | 16bit D/A converter for all axes                               |
| Scan speed                         | Up to 60ms/line at 128 data points/line                        |
| Scan drive signals                 | No (dangerous) high voltage                                    |
| 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 - 255  |
| Spectroscopy data points           | Up to 2048   |

#### Software

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



**Computer requirements**

|                         |  |
|-------------------------|--|
| Operating system        | Windows 2000, XP or newer  |
| 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 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++, ...                                      |

**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 | $\pm 10V$ , Excitation: $\pm 5V$   |
| Power supply output       | GND, +15V, -15V  |

**Nanosurf easyScan 2 Signal Module: A**

|                                     |   |
|-------------------------------------|---|
| Output signal                       | All output signals of Signal Module: S                |
| Additional analog user outputs      | 2x 16bit D/A converters, $\pm 10V$                    |
| Synchronisation output              | 1x TTL: start, end, point sync pulses, variable width |
| Additional signal modulation inputs | X-Axis, Y-Axis, Z-Axis, Tip Voltage, Excitation       |
| Free connectors                     | 2x Aux, connection made on user request               |
| Modulation range                    | $\pm 10V$ , Excitation: $\pm 5V$                      |

Additional analog user inputs 2x 16bit A/D converters,  $\pm 10V$

Additional modes Almost unlimited

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

User outputs can be modulated in Spectroscopy measurements.

## STM Measurement

| STM Scan Head:                    | 500nm                   | 1 $\mu$ m   | 500nm LC               | 1 $\mu$ m LC |
|-----------------------------------|-------------------------|-------------|------------------------|--------------|
| Maximum Scan range <sup>1)</sup>  | 500nm                   | 1.0 $\mu$ m | 500nm                  | 1.0 $\mu$ m  |
| Maximum Z-range <sup>1)</sup>     | 200nm                   | 200nm       | 200nm                  | 200nm        |
| Drive resolution Z <sup>2)</sup>  | 3pm                     | 3pm         | 3pm                    | 3pm          |
| Drive resolution XY <sup>2)</sup> | 7.6pm                   | 15pm        | 7.6pm                  | 15pm         |
| Current set point                 | 0.1-100nA in 25pA steps |             | 0.02-20nA in 5pA steps |              |

1) These are typical values, the exact values are given on the calibration certificate that is delivered with the instrument.

2) Calculated by dividing the maximum range by 16bits; atomic resolution on HOPG can be obtained with all STMs

Imaging modes Constant Current (Topography), Constant Height (Current)

Spectroscopy modes Current-Voltage, Current-Distance

Tip voltage  $\pm 10V$  in 5mV steps

Sample approach Stick-slip motor

Sample size max. 10mm diameter

## Components of the system

This section describes the parts that may be delivered with an easyScan 2 STM 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 Control-

ler. Their presence is indicated by the status lights on the top surface of the Controller when it is turned on (see section *Connectors, Indicators and Controls* (p.13)).



*Components: The easyScan 2 STM system*

1. easyScan 2 Controller with built in optional Signal Module: A or S electronics, and other modules used for AFM operation
2. USB cable
3. Mains cable
4. easyScan 2 STM Scan head(s)
5. Magnifying cover with 10x magnifier
6. STM Calibration sheet
7. This easyScan 2 STM Operating Instructions manual
8. easyScan 2 Software Reference manual
9. easyScan 2 Installation CD: Contains software, calibration files, and PDF files of all manuals
10. STM Tool set (option). The contents of the STM Tool set are described in the next section.

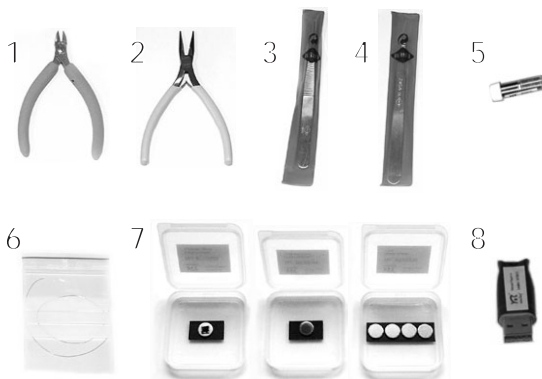
11. Vibration isolation platform (option)
12. Break-out cable (with Signal Module: S)
13. Connector box (with Signal Module: A)
14. Signal Module cables (2x) (with Signal Module: A)
15. Scripting Interface Certificate of purchase with Activation key printed on it (with Scripting Interface)
16. Instrument Case

The package may also contain easyScan 2 AFM head(s) and modules for AFMoperation; these are described in the *AFM Operating Instructions*.

Additionally, a solvent (e.g. ethanol, acetone) is needed to clean the tools. This is not included with the contents of delivery.

## Contents of the Tool set

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



*Contents of the STM Tool set*

1. Wire cutters
2. Flat Nose Pliers
3. Pointed tweezers: 00D SA
4. Rounded tweezers: 2A SA-SL

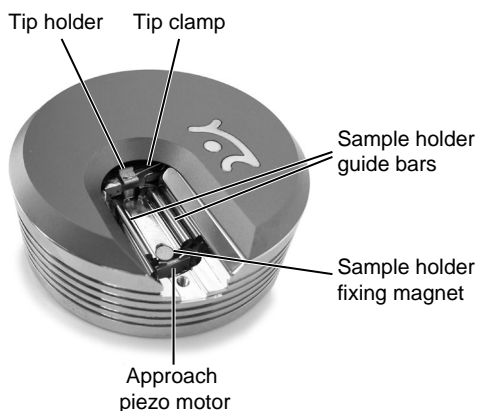
5. Sample holder
6. Pt/Ir wire: 0.25mm/30cm for making tips (option)
7. STM Basic Sample Kit (option) with HOPG (graphite), gold thin film and four empty sample supports
8. USB dongle for the Nanosurf Report software (option)

## Connectors, Indicators and Controls

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

### The Scan head



*Parts of the scan head*

### The Controller

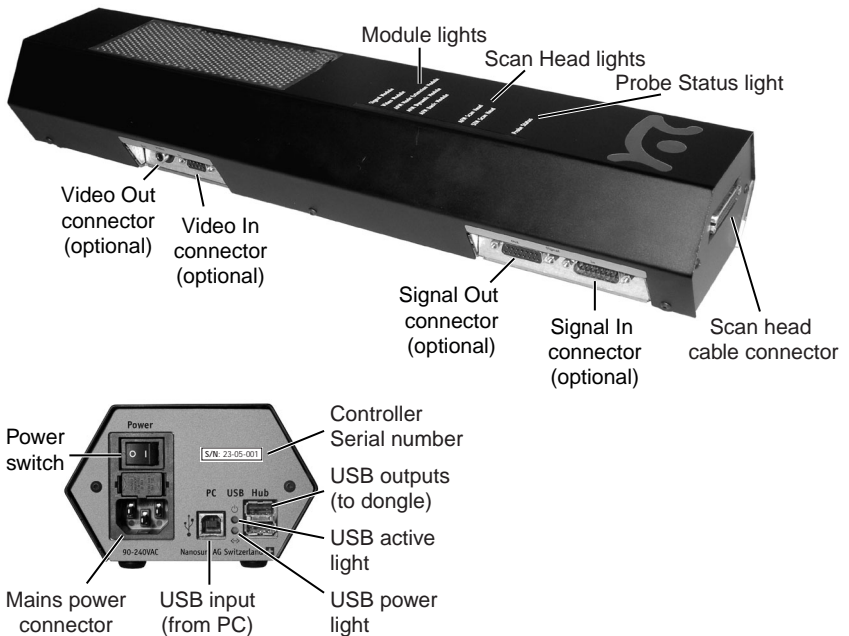
#### Status lights

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:

## THE EASYSCAN 2 STM



### *The easyScan 2 Controller*

- 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.
- 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.

### **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 STM

---

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

### Important!

To enable measurements of atomic resolution to be made the following precautions must be taken to keep equipment dust and grease free:

- Never let your fingers touch either the wire for tips (figure *Contents of the STM Tool set* (p.12), 6), the sample (*Contents of the STM Tool set*, 7) nor the parts of the STM scan head indicated in figure *Parts of the scan head*.
- Only touch the sample holder (*Contents of the STM Tool set*, 5) at the black plastic end.

## Installing the Hardware

---

### 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.

If the vibration isolation of your table is insufficient for your measurement purposes, an optional active vibration isolation table is available.



*easyScan 2 STM system*



## Installing the Basic STM Package

- Put the STM scan head (*Components* (p.11), 4) onto the vibration isolation platform (*Components*, 11).
- Fix the scan head cable under the strain relief clip on the platform.
- Connect the STM scan head to the Controller (*Components*, 1).
- 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.18).

## Installing the Signal Module: S

- Connect the Signal Module: S (*Components*, 12) to the Signal Out connector on the Controller (*The easyScan 2 Controller* (p.14)).

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*, 14) to the Signal Out connector on the Controller and to the Output connector on the Connector box.
- 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/replacing 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 light on top of the Controller shortly 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 the instrument case, so that the instrument is protected from dust.

- Turn off the instrument as described in section *Turning off the instrument* (p.41), and remove all cables.
- Remove the sample and sample holder. The tip can be left in the scanner.
- Store the sample holder in its container, and check that the silica is still blue (chapter *Maintenance* (p.56)).
- Pack all components as shown in figure *Packing*.

### **Important!**

Always put the instrument in the original Nanosurf shipping box 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.9).
- Disconnect the USB cable from the Controller.
- Turn on your computer and start Windows.

### **Important!**

Make sure you have administrator privileges before software installation. Do not run any other program while installing the scan software.

- Insert the easyScan 2 Installation CD into your CD drive.



*Packing: The easyScan 2 STM system packed in the Instrument Case*

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

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

- 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 AFM Video Module. These are installed first.

- 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 that new devices have been connected to it, and start installing the drivers. On some computers, the detection and installation process may take some time (20 seconds or more), please be patient. Once all the drivers listed below have been installed, click OK in the Step 1 Dialog.

If you have already installed the easyScan 2 software or the Mobile S software on this computer, it is possible that nothing will happen, because the drivers are installed already. In this case the drivers listed below should be displayed in the Windows device manager. If this is the case, you can also 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.

### **High Speed Serial Converter**

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

- Choose 'Automatic installation'.
- Click the default choice in all dialogs.

The USB High Speed Serial Converter is now installed.

### **USB Serial Port**

When the operating system finds the 'USB Serial Port', it asks what to do:

- Select 'Automatic installation'.
- Click the default choice in all dialogs.

The USB Serial Port is now installed.

**USB Video Adapter**

The USB Video Adapter driver is only installed if the Controller contains a Video Module. When the operating system finds the 'USB Device', it asks what to do to install the 'USB Video Adapter':

- 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.

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

**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, unless the 'Program Files' directory has a different name in your language of the Windows operating system.

**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 it is connected to.
- The Controller and its drivers must be installed when installing the Nanosurf Scripting Interface.

## 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 STM* (p.16). These steps are preparing and installing the STM tip, selecting a sample stage, and preparing the sample.

## Initialising the Controller

---

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

First all status light on top of the Controller shortly 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 in the software, and the module status lights start lighting up one after the other. When initialisation is completed, a Message 'Starting System' is shortly displayed in the software 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.

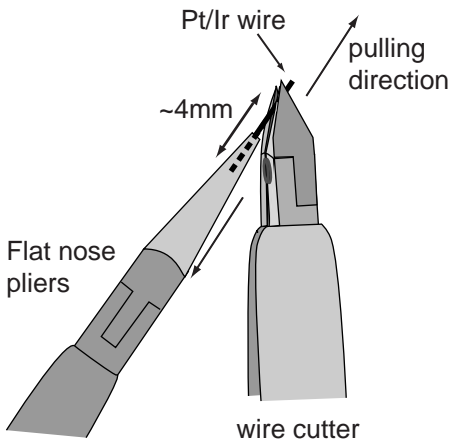
## Preparing and installing the STM tip

---

The STM tip can be prepared and installed by yourself. This is the most difficult part of your preparations. It usually needs patience and some practise to get the first good tip. Only an accurately cut tip enables optimal measurements. Therefore, cutting and installing should be carried out with great care. On delivery, the tip with which the STM was calibrated in the factory is installed in the head. This tip should give atomic resolution, so

you may wish to try to use this tip before preparing your own. Before cutting the tip:

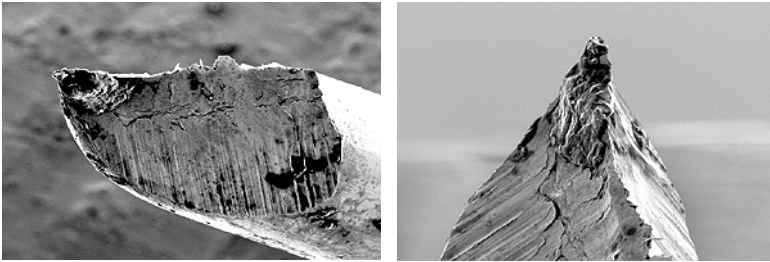
- Clean the cutting part of the wire cutters (figure *Contents of the STM Tool set* (p.12), 1), the Flat nose pliers (*Contents of the STM Tool set*, 2) and the pointed tweezers (*Contents of the STM Tool set*, 3) with ethanol.
- Only touch the Pt/Ir wire (*Contents of the STM Tool set*, 6) with these tools.
- Remove the old tip from the instrument using the pointed tweezers.
- If the tip wire is still long enough, you may try to cut the same wire again, otherwise take the Pt/Ir wire. To prepare the tip:
- Hold the end of the wire firmly with the plier.
- Holding the wire with the pliers, move the cutters at a length of approximately 4mm, as obliquely as possible (figure *Cutting the STM tip*).



*Cutting the STM tip*

- Close the cutters until you can feel the wire, but do not cut the wire.
- Pull in the direction shown in the figure. The tip needs to be torn off rather than cleanly cut through, in order to get the required sharp tip.





*STM tip: Scanning Electron Microscope images of an STM tip*

- Use the pointed tweezers to hold the tip wire with just behind the tip.
- Release the flat pliers.

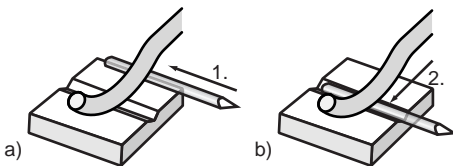
**Important!**

- Do not touch the end of the tip with anything.
- Ensure that the tip wire is straight.
- Do not twist the tip clamp in the open part of the scan head nor lift it too high.

The procedure for mounting the tip under the tip clamp depends on the type of clamp on your scan head:

**Single clamp**

Proceed as is illustrated in figure *Mounting the tip under the single clamp*.



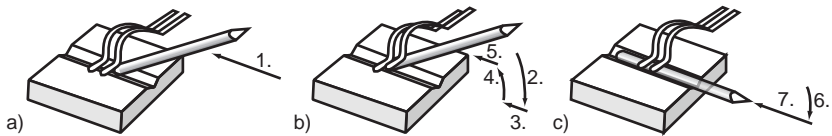
*Mounting the tip under the single clamp*

1. Put the tip wire on the tip holder parallel to the groove in the tip holder, so that it crosses below the tip clamp (figure a).
2. Move the tip wire sideways until it is in the groove in the tip holder (Figure b).

The freshly cut tip should be securely held under the clamp and extend about 2-3mm beyond the tip holder. The tip is now installed.

### Double clamp

Always use the following procedure for mounting the tip under the double clamp (figure *Mounting the tip under the double clamp*). Using a different procedure may cause a gradual deterioration of the measurement quality due to loosening of the clamp.



*Mounting the tip under the double clamp*

1. Hold the tip wire at a slight angle, and move it along the groove against the first clamp, so that the end of the wire is under the clamp (figure a).
2. Lower the wire so that it lifts the first clamp (figure b).
3. Push the wire in, until it touches the second clamp.
4. Lift the wire.
5. Push the end of the wire below the second clamp.
6. Lower the wire so that it lifts the second clamp (figure c).
7. Push the wire under the second clamp.

The freshly cut tip should be securely held under the clamp and extend about 2-3mm beyond the tip holder. The tip is now installed.

## Installing the sample

---

### Preparing the sample

The STM can only examine electrically conductive materials. Nevertheless the choice of material is rather small because the surface of the sample must not oxidise, be totally clean and mirror-like to obtain useful results. Because of this some of the samples need special preparation.

**Important!**

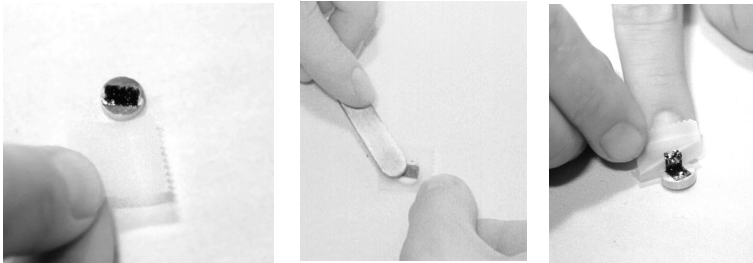
Never touch the sample's surface once it is prepared.

**Gold thin film**

Cleaning the sample is neither possible nor necessary. Never touch the sample with your fingers or put it upside down anywhere, this will only make it unusable faster.

**Graphite**

The surface of the graphite sample can be cleaned when it is very dirty or uneven. Due to the layered structure of graphite this can easily be done using a piece of adhesive tape (figure *Cleaving graphite*):



*Cleaving graphite*

- Put the sample on the table using the pair of tweezers.
- Stick a piece of adhesive tape gently to the graphite and then pull it off again: The topmost layer of the sample should stick to the tape.
- Remove any loose flakes with the pair of tweezers.

The graphite sample is now ready for use and may not be touched.

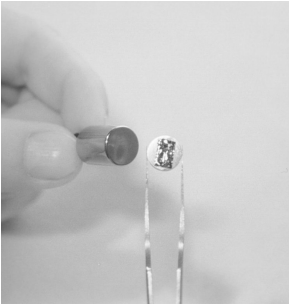
**Installing the sample****Important!**

Always store the sample holder in its package, in order to prevent corrosion (chapter *Maintenance* (p.56)).

- Unpack the sample holder (figure *Contents of the STM Tool set* (p.12), 5)

touching only its black plastic handle.

- Put the prepared sample onto the magnetic end of the sample holder using a pair of tweezers (Figure *Putting the sample on the holder*):



*Putting the sample on the holder*

- Place the sample holder carefully in the scan head so that it doesn't touch the tip, and the sample is not pulled from the sample holder by the magnet that holds the sample holder in place (figure *Placing the sample holder in the scan head*).



*Placing the sample holder in the scan head*

- Put the sample holder down on to the sample holder guide bars first and release it gently on to the approach motor's support.

## First Measurements

---

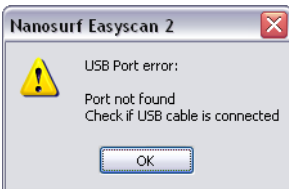
In this chapter, step by step instructions are given as to how to operate the microscope and make a simple measurement. More detailed explanations of the software and the system are given in the Software Reference manual.

## 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

---

Prepare the instrument as follows (Refer to chapter *Preparing for Measurement* (p.23) for more detailed instructions):


- Prepare and install a Pt/Ir tip.
- Install the HOPG sample.

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-STM.par' from the directory with default easyScan 2 configurations. Usually this is 'C:\Program Files\Nanosurf\Nanosurf easy-Scan 2\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 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 resolution limits or timing limits. The desired value is automatically changed to the nearest possible value.

## Approaching the sample

---

To start measuring, the sample must be very close to the tip to enable a tunneling current to flow. Approaching the sample without touching the tip is a delicate operation 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 away from the sample. In this case, the tip is probably dam-

aged, so you will have to start over again with preparing a new tip.

**green**

The approach is finished, the Z-scanner is within the measuring range, tunneling current should be flowing.

## 1. Manual Coarse approach

- Push the sample holder carefully to within 1mm distance of the tip.



*Manual Coarse approach*


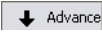
- If the tip is pointing toward a rough area of the sample, try turning the sample holder around its axis so that the tip points towards a flat, mirror-like area of the sample.
- Put the magnifying cover ([Components](#) (p.11), 5) over the scan head without touching the sample holder.
- Place the magnifier so, that you can see the mirror image of the tip in the sample.

The cover reduces air flow around the scan head and reduces thermal drift in measurements at atomic scale.



## 2. Manual approach using the piezo motor

The piezo motor is operated using the Approach Panel in the Positioning window. To open this window:

- Click the Positioning icon  in the Navigator.
- Watch the distance between tip and sample with help of the magnifier.  
Now click  in the Approach Panel to move the sample towards the tip to a distance of a fraction of a millimetre.

You should only just be able to see the gap between the tip and its mirror image (figure *Tip-sample position*). The smallest visible gap depends on the observation angle of the magnifier and the lighting of the sample.




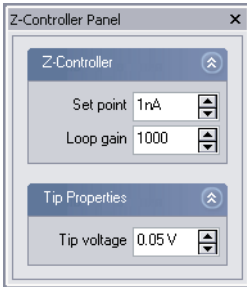
*Tip-sample position: Position at the end of the Manual approach with the piezo motor.*

If you can not see the motor has moving, clean the sample holder guide bars and the surfaces of the approach motor following the procedure described in chapter *Maintenance* (p.56).

## 3. Automatic final approach

In the last step, the tip approaches the sample, until the set point is reached. First check that the set point and the feedback speed are set properly:

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



- Set 'Set point' (tunneling current) to 1.00nA.
- Set Loop gain (the speed of the feedback loop) to 1000 for normal heads, or to 200 for LC heads.
- Set "Tip voltage" (tip-sample-voltage) to 50mV.

Now that the feedback settings are correct, the automatic final approach can be started:

- Click  in the Approach Panel.

The sample holder is now stepped towards the tip with the help of the piezo motor. After each step, the Z-scanner is fully retracted from the sample, and released to move towards the sample. The approach is finished if the current determined by Set point is detected before reaching the maximum extension of the Z-scanner, otherwise the approach motor will continue with the next step. Due to the motion of the Z-scanner, the Probe Status light will blink red-green-orange-red-green-etc.


If the approach was finished successfully, the probe status changes from blinking to green and the message box 'Approach done' appears.

- Click the 'OK'-button.

If the status light change to red instead of green, or if the approach has not finished after 10 - 20s, try to decrease the tip-sample distance a little more using manual operation of the piezo motor. If the automatic final approach never works, refer to chapter *Problems and Solutions* (p.58) for the next steps to take.

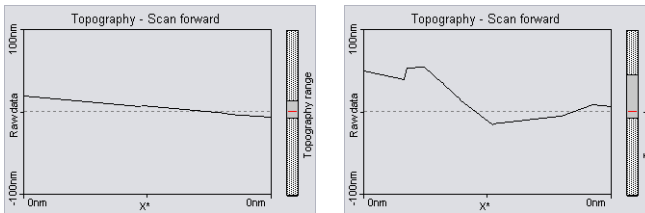
## Starting a measurement

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

- Click  to open the Imaging window.

The STM has already started imaging the sample.

If the preparation of tip and sample and the approach were successful, images of the measurement will show a more or less straight line in the Line graph (figure *Starting image, left*) and a plane in the Color map. Watch the displays for a while until the Color map-image has been drawn about three times.



*Starting image: left: a good Line graph; right: a 'nervous' Line graph.*

A 'nervous' line in the Line graph indicates a bad tunneling contact (figure *Starting image, right*). Usually this is caused by the tip being too blunt or instable. This means that you should stop measuring and cut a new tip:

- Click  and follow the instructions of the chapter *Problems and Solutions* (p.58).

If the line in the Line graph is calm and reproduces consistently, you can continue with the next section.

## Achieving atomic resolution


You prepared your measurement so that the Topography in the Line graph is reproducing stably. Now the scan range has to be decreased in order to observe the atomic structure.

Reminder: Measurements on the 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. It is best to let a promising measurement run for some time to let it stabilize thermally.

To decrease the Imaging area:

- Click the Color map chart to make it active.

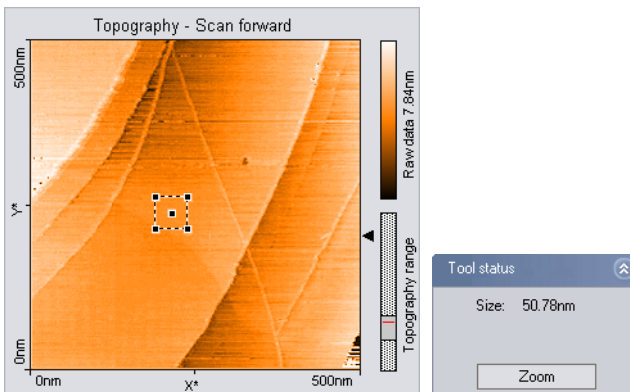
A gray square is now drawn around the Color map chart.

- Click  Zoom .

The mouse pointer becomes a pen when moving over the selected chart and and the Tool Results Panel opens.

- Move the mouse cursor to a ‘flat’ region (similar color) in the Color map and click on it.

The software will now draw a square that indicates of the new scan range. The size of the new scan range is displayed in the Tool Results Panel. If no flat region is available, refer to chapter [Improving measurement quality](#) (p.42) for further instructions.

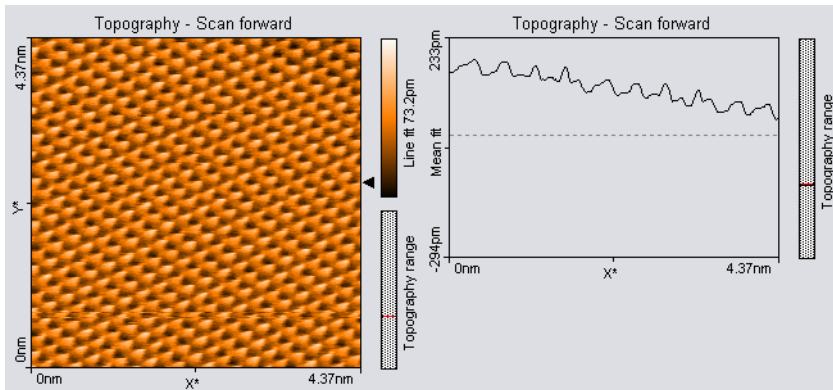


- Change the size of the new scan range to about 30-50nm by clicking and dragging a corner of the square with the mouse cursor.
- Double click the chart when the scan new area is set as you want it. You can abort the zoom function by clicking with the right mouse button.

The imaging settings are now set in such a manner that the new measurement will correspond to the area that was indicated by the square.

The image size should be decreased even further, considering that one nanometer is the diameter of between four and eight atoms. Atomic arrangements can normally be made out at an Image size of about 4nm:

- Set the Image size in the Imaging panel to 4nm.
- Some parts of the scan head react to the slightest temperature changes. As these thermal 'movements' influence the measurements on the nanometer scale, the sample has to be scanned as fast as possible.
- Set the Time/Line in the Imaging Panel to 0.06s for atomic resolution.
- You may also try to decrease noise by decreasing the Loop gain of Z-Controller.
- Try varying these parameters to get a nice image of the graphite surface.



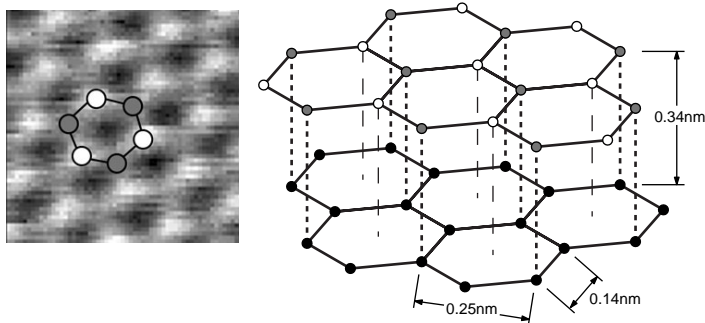
*Good images of a successful measurement*

## The graphite surface

In a good color map chart of graphite you will see a pattern consisting of white, grey and black spots. It looks like a three dimensional image of balls lying next to each other, but be careful: these are not the single atoms!

To interpret the image correctly you must first be aware that bright spots show high points and dark spots low ones.


In the lattice model of graphite one can see that there are two different positions of the carbon atoms in the graphite crystal lattice: One with a neighbouring atom in the plane below (grey) and one without a neighbour in the lattice below (white). As a consequence, the electrical conductivity of the graphite surface varies locally slightly so that the atoms without neighbours appear higher than the others.




*Graphite surface: left: measurement; right: lattice model*

This also causes the lattice constant between the bright 'hills' to have the higher than normal value of 0.25 nm.



## 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  Photo button. The behaviour of this button depends on whether a measurement is in progress or not.

When a measurement is in progress, and  Photo 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:

- Click  to stop scanning.
- 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:



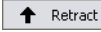
- Activate the measurement document by clicking in its window, or by selecting it in the 'Windows' menu.
- Select the menu 'File>Save as...'. Select the folder and file name where you would like to store the measurement.

The stored measurements can now be loaded with the easyScan 2 software and the Nanosurf Report software for later viewing, analysis and printing (see also *Software Reference* manual).

## Finishing

---

Once you are done measuring:

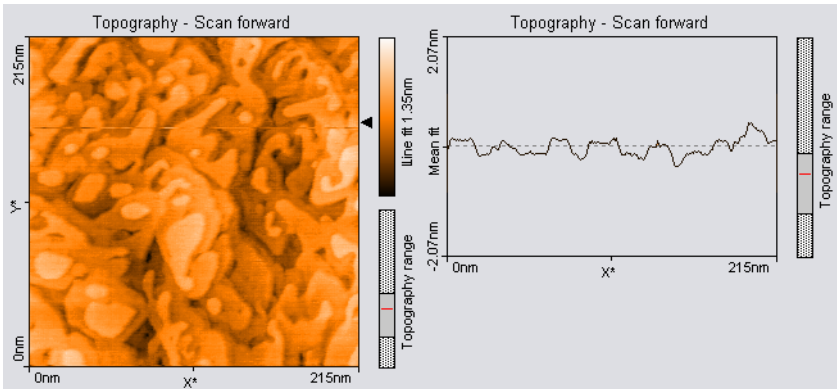
- Click  to stop measuring.
- Retract the sample holder first by using  then .
- Remove the magnifying cover from the scan head.
- Remove the sample holder with one hand.
- Remove the sample from the sample holder and store it in its case with the other hand.
- Store the sample holder in its container.

## Measuring Gold

---

It is more difficult to obtain good images of a gold. Atomic structures are difficult to observe because the electrons on the surface are much more homogeneously distributed than in graphite. But with some training the mono-atomic gold steps can be observed.

## FIRST MEASUREMENTS



Due to the fact that the gold sample cannot be cleaned by simple means it is possible that with time contaminants may prevent you from obtaining good results.

### Tip:

Before you do any experiments with the gold sample it is necessary to practise on the graphite sample. You should also test the quality of your tip using the graphite sample.

Proceed as you did with the graphite sample, but there are two exceptions to note:

- Set the Tip voltage in the Z-Controller panel to 0.5V.
- Set the Time/Line in the Imaging Panel to 0.3s.

If you do not get stably reproduced scan lines you should look for another clean measuring spot.

- First try with  followed by . If that does not change much retract the sample holder and rotate it a little by hand. Repeat the approach.
- If the image reproduces stably, select a Image size between 200 and 300nm.


Evaluate your measurements in the same way as you did with the graphite images, zoom, measure, save etc.



## 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.

- 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.

For an in depth introduction to the Nanosurf Report software, refer to the Introduction section of the Nanosurf Report online help.

## Turning off the instrument

---

- Follow the instructions from section *Finishing* (p.39).
- 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.

If you perform measurements regularly leave the instrument with the Magnifying cover over the scan head to protect it against dust.

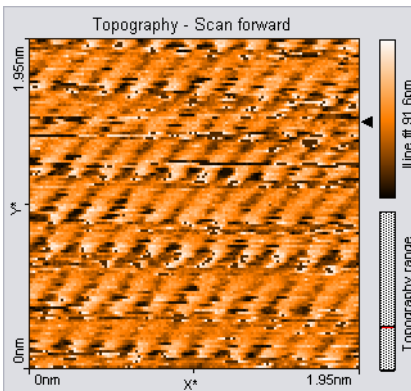
If you do not operate the instrument for several weeks, store the instrument as is described in section *Storing the Instrument* (p.18).

## Improving measurement quality

### Judging and improving tip quality

From the quality of the measured images the quality of the tip and consequently that of the tunneling contact can be observed. A good tunneling contact is necessary for high quality images of atomic resolution.

If during a good measurement the image quality diminished dramatically, the tip has most probably picked up some particles or you are near a step in the surface.



- Continue measuring for a while (4-5 images); the tip may eventually lose the picked up material again.

If this does not help, try to induce changes at the tip's end using one of the following procedures:

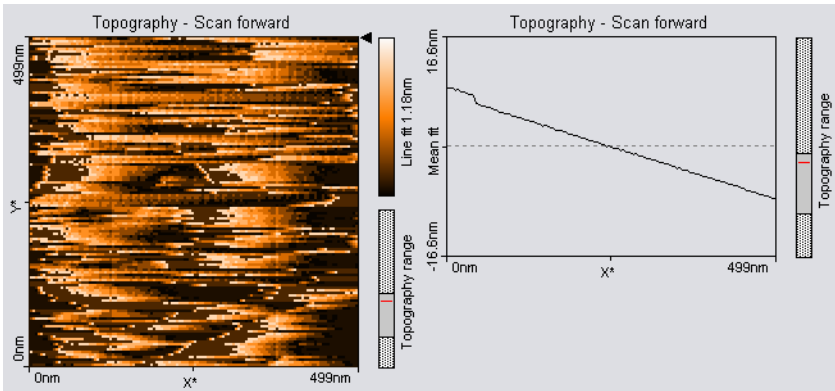
- While measuring increase the gap voltage in the 'Feedback Panel' to 2V then reduce it to the old value again.
- Increase the tunneling current to 20nA for a short time then reduce it to its old value again.
- Retract the sample, then perform a new approach.

If no improvement can be seen after going through these procedures, you have to prepare a new tip:

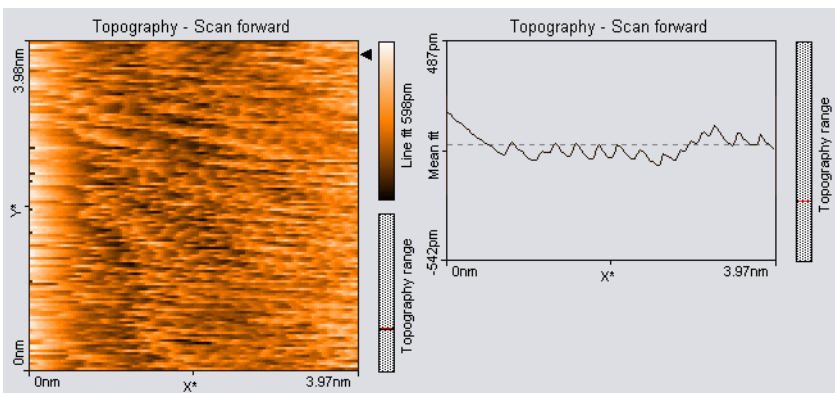
- Follow the instructions from section *Finishing* (p.39).
- Follow the instructions in section *Preparing and installing the STM tip* (p.23).

**Examples of images made with unusable tips**

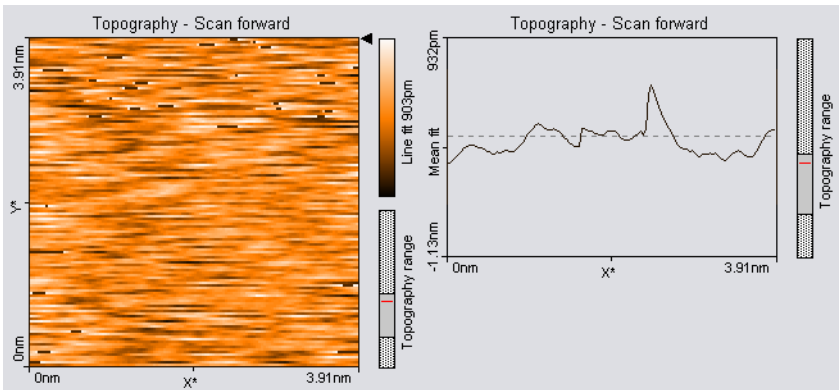
Prepare a new tip when your image looks like one of the examples below.



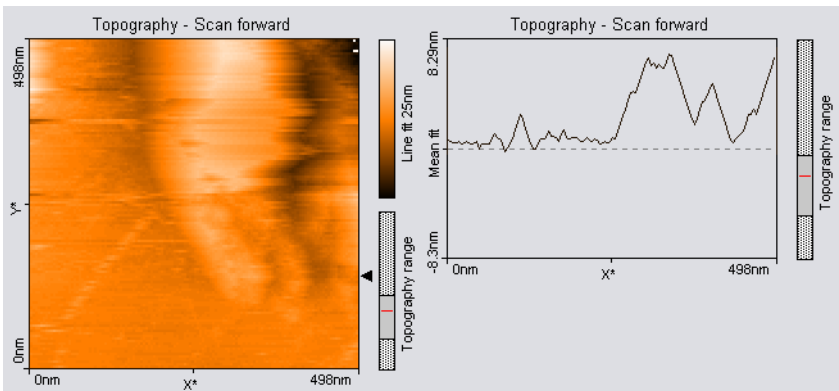
*The color map image consists of uncorrelated lines.*



*The image is 'smeared out' on one border (here on the left border).*



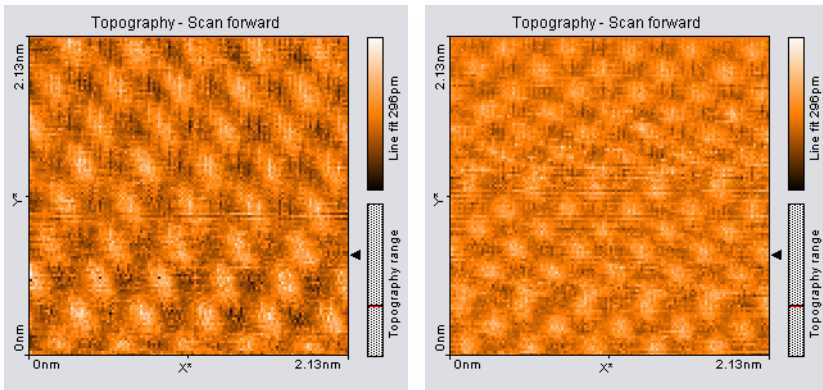
*Each image looks different.*



*The scan lines in Line graph are unstable and the image in the Color map is blurred.*

## Decreasing thermal drift

Temperature variations cause so-called 'thermal drift'. This will cause images to be distorted. This effect can be observed when e.g. the upward scan is very different to the downward scan showing two differently distorted lattices.



*Consecutive upward and downward scan showing thermal drift.*

Thermal drift is very clearly perceptible on an atomic scale. Variations of  $0.1^{\circ}\text{C}$  already cause variations in the length of e.g. the sample holder (steel) of several nanometers.

To decrease thermal drift, keep the measurement running for some time to let the system stabilize (up to about one hour).

## Removing interfering signals

Interfering signals can be recognised because they have a fixed frequency, usually a multiple of the local mains frequency (50 or 60Hz) 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).
- Electrical interference (in the electronics, or in electrical forces in the tip-sample interaction).

### **Mechanical vibrations**

To find out if the interference is due to mechanical vibrations:

- Measure the frequency of the 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 option).

### **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.
- Remove interfering electromagnetic field sources, such cathode ray tube displays, loudspeakers, ...

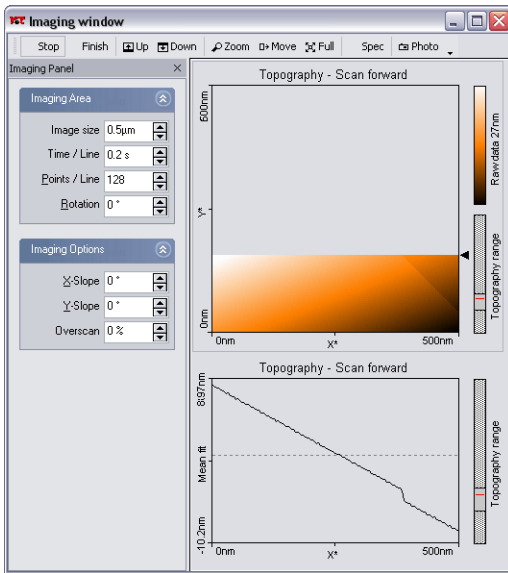
## **Adjusting the measurement plane**

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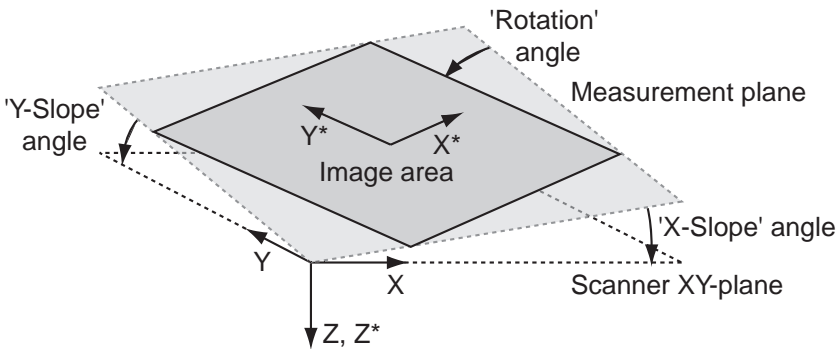
Ideally, the plane of the measurement and the sample surface lie in the XY-plane of the scanner. But mostly the sample plane is tilted with respect to that ideal plane, as shown in figure *Maladjusted slope*. In this case, the sample cross section in the  $X^*$  measurement direction, as shown in the Line graph window, has a certain slope. This slope depends on the direction of the  $X^*$  direction and therefore on the rotation of the measurement, as shown in figure *Slope*.

The measurement plane should be parallel to the sample plane because:

- When the Average, Plane fit or higher order filters cannot be used because they would distort the image, it is easier to see small details on the sample



*Maladjusted slope: Measurement with improperly set X\*-slope.*



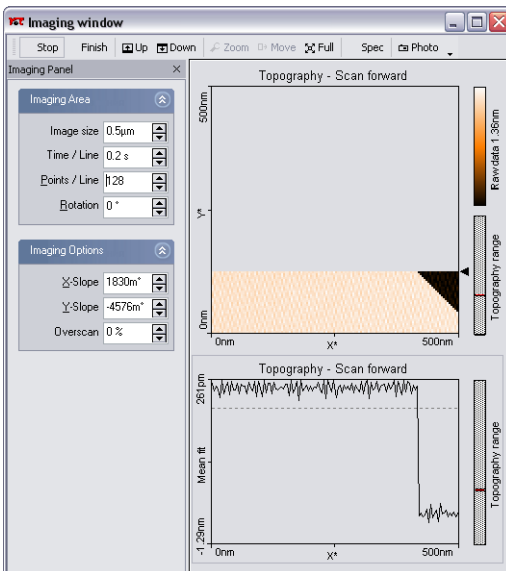
*Slope: Sample's and measurement orientation before slope adjustment*

surface when the planes are parallel.

- The Z-Controller functions more accurately, because it does not have to compensate for the sample slope.

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:

- The slope correction is only available with the Standard level and the Advanced level user interface mode. Open the User interface dialog via the menu 'Options/Config user interface, and select one of these modes.
- Measure the slope in the Line graph using the angle tool (see *Software Reference*). 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.



*Charts 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  $0^\circ$ . The Line graph shows the X-slope again.

## Measurement modes

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The surface can be scanned in two different ways: in the Constant current and Constant height mode.

In the Constant current mode, the tunneling current is kept constant by the Z-Controller. The output of the Z-Controller thus corresponds to the height of a surface of constant tip current. This output is then recorded as a function of X and Y position, and is displayed as the Topography signal.


In the Constant height mode on the other hand, the tip does not follow a surface of constant tip current. Instead the variation of the tunneling current is directly recorded as a function of the X and Y position in plane parallel to the sample surface.

The easyScan 2 STM is normally configured to measure in the Constant current mode. To switch to the Constant height mode, you could theoretically just turn off the Z-Controller. However, several problems arise:

- The tip would crash into the slightest unevenness of the surface.
- The scan plane of the scanner must be very well adjusted to the plane of the sample.
- The thermal drift in the Z-Direction will cause the tip to rapidly move away from the sample, or even worse, to be pressed into it.
- These problems can for a large part be avoided by setting the Loop-gain to a very low value. Thus, the feedback loop can follow the slow movement of the sample caused by thermal drift and the sample plane, but not the fast height changes due to the presence of the atoms.

To measure in Constant height mode:

- Find a flat area of the sample by imaging it in Constant current mode, and zoom in on this area.
- Open the User Interface configuration dialog using the menu 'Options>Config User Interface...'
- Set the User Interface Mode to 'Standard level' or 'Advanced level'.

- Click  to open the Z-Controller Panel.
- Set I-Gain to 4.
- Set P-Gain to 0.

To visualize the current:

- Click on a Color map chart in the Imaging Window.
- Set the Input channel to 'Tip Current' in the chart bar.

The bar next to Color map should now display the text 'Tip Current' and have the units 'pA' or 'nA' instead of 'nm'.

## The Signal Modules

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The Signal Modules consist of both electronics modules that are built into the Controller and a break-out Connector that is externally attached to the Controller. The Signal Modules can be used for monitoring the signals from (Signal Module: S) and adding functionality to (Signal Module: A) the easyScan 2 system. 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.16).

### Signal Module: S

---

The Signal Module: S can be used for monitoring signals from the STM 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 affected by Image X-Pos and the Imaging Area Rotation.             |
| Y-Axis      | Y-Position command of the Scanner. Is 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 ramp that drives the approach motor.   |
| Excitation  | no signal (AFM only)   |
| Deflection  | The tip current (see below)  |
| Amplitude   | no signal (AFM only)   |
| Phase       | no signal (AFM only)   |

*Monitor Signals*

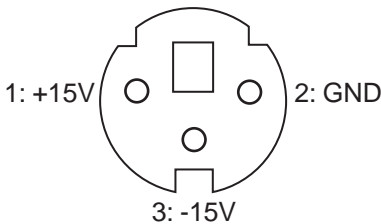
The calibration of the monitor signals can be found by looking up the signal calibration in the Scan Head Calibration Dialog, reached via the menu 'Options>Config Scan Head...'. The magnitude of the physical signal can be calculated from the Monitor Signal voltage using the formula:

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

The Tip Current signal depends both on the Tip voltage, and the tunneling current. The current can be calculated using the formula:

$$TipCurrent = \frac{(TipCurrentSignalVoltage - TipVoltage)}{10[V]} \cdot Maximum + Offset$$

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: as seen from outside.*

## Signal Module: A

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The Signal Module: A can be used for adding functionality to the easyScan 2 system in addition to the applications for 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* (p.52) and *Signal Module: A Signals*.

| <b>Signal name</b> | <b>Function</b>   |
|--------------------|---|
| Sync               | An output that can be used to synchronise external equipment with the Controller. This feature will be described in more detail in a future manual version (refer to the Nano-surf Web site).                                       |
| 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 added to the Tip-voltage set in the software.  |
| Excitation Input   | no function (AFM only)  |
| 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.   |

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*Signal Module: A Signals*

| <b>Signal name</b> | <b>Function</b>  |
|--------------------|--|
| 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.

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](#) (p.53).

## Using the User Inputs and Outputs

The user Inputs and Outputs can be configured using the User Input/Output section of the Operating Mode Panel. This Section is only available in the Advanced Level User Interface.

## Maintenance

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

### Scan head

It is very important to prevent the sample holder and the open part of the scanner from becoming dirty or damp.

#### Protecting the sample holder against corrosion

The approach motor will not run well if the sample holder is dirty or corroded.

The sample holder is made of magnetic steel and therefore suffers from corrosion in a humid environment. To reduce corrosion and increase life expectancy, the sample holder must be stored in its container together with the moisture absorbing silica container. The container is waterproof but not airtight. The silica contains a blue indicator which turns pink when saturated. To regenerate the silica:

- Heat the silica container at 100°C for at least two hours until it turns completely blue again.



### Cleaning parts of the approach motor

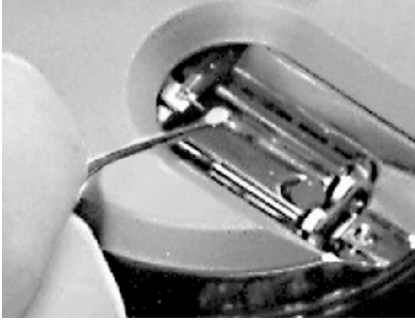
If you have touched the metal part of the sample holder, or it has otherwise become dirty, or the approach motor does not move:

- Take a soft cloth, if necessary moistened with alcohol.
- Clean the holder by moving the cloth along the sample holder in the axial direction, do not move it around its circumference.
- Let the parts dry before operating the motor again.



If the approach motor still does not move:

- Take a cotton swab, if necessary lightly moistened with alcohol.



*Cleaning the sample holder guide bars*

- Clean the sample holder guide bars (figure [Cleaning the sample holder guide bars](#)).
- Clean the surfaces of the piezo motor that touch the sample holder.
- Clean the tip holder (remove the tip when doing this).
- Let the parts dry before operating the motor again.

## **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

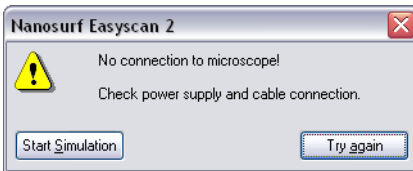
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## Common problems

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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 section [Nanosurf support](#) at the end of this chapter.

### 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.

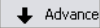

### USB Port error



The USB cable is not properly connected. In this case the USB power light on the Controller rear panel (figure [Parts of the scan head](#) (p.13)) does not light up.

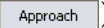
Check that the USB cable is properly connected.

## Manual approach is too slow / stops sometimes

If the manual approach using the piezo motor (buttons  and ) is affected:

- Clean the sample holder guide bars and the surfaces of the approach motor following the procedure described in chapter *Maintenance* (p.56).

## Automatic final approach is too slow / stops sometimes

Even if the manual approach works, the automatic final approach (button ) may not work.

- Clean the sample holder guide bars and the surfaces following the procedure described in chapter *Maintenance* (p.56).

If cleaning does not help the step size may be too small:

- Open the User Interface configuration dialog using the menu 'Options>Config User Interface...'.
  - Set the User Interface Mode to 'Standard level' or 'Advanced level'.
  - Increase the value of Appr. Speed in the Approach Options section of the Approach Panel by a few percent until the approach works.

Now the motor moves the sample holder with larger steps during automatic approach.

- Save the new value of Appr. Speed using the menu 'File>Parameters>Save'.

## Automatic final approach crashes the tip into the sample

In this case the motor moves the sample holder towards the tip with too large steps:

- Open the User Interface configuration dialog using the menu 'Options>Config User Interface...'.
  - Set the User Interface Mode to 'Standard level' or 'Advanced level'.
  - Decrease the value of 'Appr. Speed' in the Approach Options section of

the Approach Panel by 10%.

- Repeat the approach with a new tip. If the approach fails again, reduce 'Appr. Speed' further.
- Save the best 'Appr. Speed' value using the menu 'File>Parameters>Save'.

## Image quality suddenly deteriorates

There are several possible causes:

### Z-Drift

The tip drifted outside the Z-range of the scanner. In this case, the probe status light will either light up orange or red. If the light is orange, the tip has lost contact with the sample:

- Click  in the Approach Panel then repeat the steps in chapter *First Measurements* (p.29).

If the light is red, the tip has drifted into the sample. You can try to move the sample surface within the Z-range of the scanner, although the tip may already have been damaged:

- Click  in the Approach Panel.

If the light is still red after withdrawing, prepare a new tip (section *Preparing and installing the STM tip* (p.23)).

- Click .

### XY-Drift

The scanner may have drifted close to a deformity in the sample's surface. Try to find a different measurement position:

- Increase the scan range.
- Zoom into a flat area.

**Tip modification**

The tip may have picked up some particles or other material from the sample surface. In this case, follow the instructions given in chapter *Improving measurement quality* (p.42).

**Nanosurf support**

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**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](http://www.nanosurf.com).
- Click on support.
- Enter the combination of serial number and 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.'

- If an error message was displayed: The exact text of the message, or at least its start.
- 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.

## STM Theory

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### What is STM?

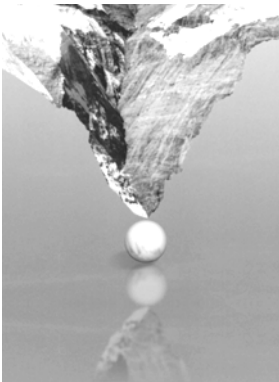
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Microscopy is one of the most exciting scientific techniques. The insight into small dimensions has led to a new understanding of the structure of materials and forms of life.

With the help of the scanning tunneling microscope (STM) it is possible to look into the fascinating world of the atoms. This completely new microscopy technique works without focusing elements and features atomic resolution (laterally and vertically).

The Scanning Tunneling Microscope 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.

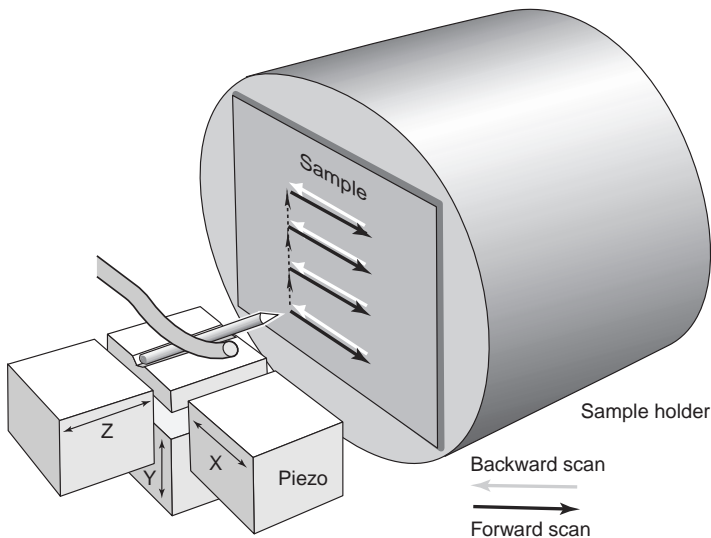
In the STM, a small sharp conducting tip is scanned across the sample's surface, so close that the so-called 'tunneling current' can flow. With the help of that current the tip-surface distance can be controlled very precisely. Therefore an enormous resolution is achieved so that the atomic arrangement of metallic surfaces can be 'probed'.



To be able to get such excellent pictures of atomic resolution is almost incredible, considering that the size of the atom in relation to the tip is that of a golf ball to a mountain.

## Scanning with the easyScan 2 STM

In the easyScan 2 STM, a platinum-iridium tip is moved in three dimensions using piezo-crystal translators that are driven with sub-nanometer precision.

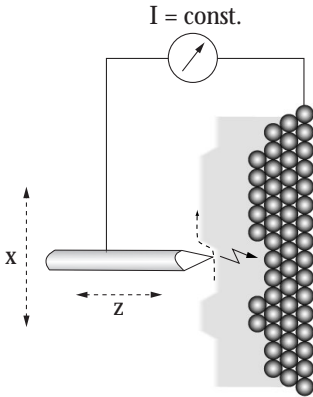


The sample to be examined approaches the tip within a distance of 1 nanometer ( $1\text{nm} = 1 / 1\,000\,000\,000\text{ m}$ ). Classical physics would prohibit the appearance of electrons in the small gap between a tip and a sample, but if a sharp tip and a conducting surface are put under a low voltage ( $U \sim 0.1\text{V}$ ) a very small tunneling current ( $I \sim 1\text{nA}$ ) may nevertheless flow between tip and sample. This tunneling current is due to a quantum physics effect.

The strength of the tunneling current depends exponentially on the distance between the tip and the sample (usually referred to as Z-distance). This extreme dependence on the Z-distance makes it possible to measure



the tip-sample movement very precisely. One of the three piezo crystals, the Z-piezo, can now be used in a feedback loop that keeps the tunneling current constant by appropriately changing the Z-distance.

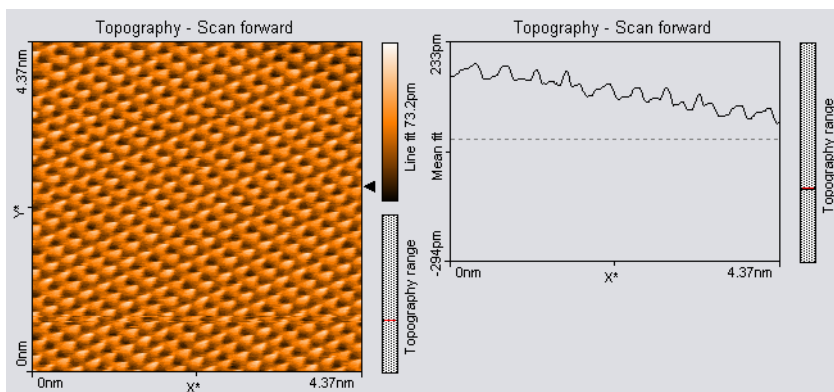


*Feedback loop: The feedback loop maintains a constant tunneling current between the tip and the sample during motion in the X-direction by changing the Z-direction (viewed from top)*

To obtain an image of the sample, the tip is scanned using the X- and Y-piezo crystals. The feedback loop will now let the tip follow the structure of the sample's surface. A height image can now be made by recording the position of the Z-feedback loop as a function of the XY-piezo position. This 'landscape' (or topography) of the atomic surface is then drawn line by line on the computer screen.

The sample can also be scanned in a second mode: When the feedback loop is slowed down very much, the tip scans at a fixed distance from the sample (constant height mode). This time the variations in the tunneling current are measured and drawn line by line on the computer screen. However, this mode only works when the sample is atomically flat, because the tip would otherwise 'crash' in to the sample.

# STM THEORY



*STM image of graphite*