CHAPTER 1:

Preparing for measurement
1.1: Introduction

Once the system has been set up (see Chapter 2: Installing the traxSTM (page 19)), the instrument and the sample have to be prepared for measurement. The preparation consists of three steps: Initializing the traxSTM system, Preparing and installing the STM tip, and Installing the sample.

1.2: Initializing the traxSTM system

To initialize the traxSTM system:

1. Make sure that the traxSTM system is connected to the mains power and to the USB port of the control computer.

2. Turn on the power of the traxSTM system by pressing the power button at the back of the controller housing.
   A blue power LED on the side of the system will light up.

3. Start the traxSTM Control Software on the control computer.
   Now a message “Controller Startup in progress” is displayed on the computer screen.
   When initialization is completed, a message “Starting System” is briefly displayed on the computer screen.

1.3: 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 a tip:

1. Clean the cutting part of the wire cutters (in the manual Figure 1-2: Contents of the tool set (page 15), item 1), the Flat nose pliers (item 2) and the pointed tweezers (item 3) with ethanol.
   Only touch the Pt/Ir wire (item 6) with these tools.

2. 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 cut the Pt/Ir wire.
To prepare the tip:

1. Hold the end of the wire firmly with the pliers.

2. Holding the wire with the pliers, move the cutters at a length of approximately 4 mm, as obliquely as possible (Figure 1-1: Cutting the STM tip).

3. Close the cutters until you can feel the wire, but do not cut the wire.

4. Pull in the direction shown in Figure 1-1: Cutting the STM tip. The tip needs to be torn off rather than cleanly cut through, in order to obtain the required tip sharpness.

5. Use the pointed tweezers to hold the tip wire with just behind the tip.

6. Release the flat pliers.
To mount a newly prepared tip:

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 1-3: Mounting the tip under the tip clamp, A*).

2. Move the tip wire sideways until it is in the groove in the tip holder (*Figure 1-3: Mounting the tip under the tip clamp, B*).

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

![Figure 1-3: Mounting the tip under the tip clamp](image)

The tip is now installed.

### 1.4: Installing the sample

#### 1.4.1: Preparing the sample

**IMPORTANT**

- Never touch the end of the tip with anything.
- Ensure that the tip wire is straight.
- Do not twist the tip clamp in any way, nor lift it up too high.

The STM can be used to examine electrically conductive materials. In practice, however, the choice of material is more limited, because the surface of the sample must be totally clean and mirror-like to obtain useful results, and it must be in a non-oxidized state to be conductive. Because of this, some samples need special preparation.
1.4.2: Nanoscience Instruments samples

Nanoscience Instruments delivers various optional samples, which are usually packed in the traxSTM STM Tool Set. These samples are briefly described here. Further samples are available in the STM Extended Sample Kit, which contains its own sample description.

All samples should be stored in their respective box. This way, it should not be necessary to clean them. Cleaning of the samples is generally not advisable (unless indicated below), because their surfaces are often rather delicate.

Graphite (HOPG) on sample support

This sample can be used for STM as well as AFM measurements. In STM measurements, atomic resolution can be obtained on this sample.

Sample specifications:
Size: 5 mm × 5 mm
Material: Highly Oriented Pyrolytic Graphite (HOPG)
Sample support: Magnetic Steel disc, galvanized with Nickel.

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 1-4: Cleaving graphite):

1. Put the sample on the table using a pair of tweezers.
2. 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.
3. Remove any loose flakes with the tweezers.

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

Figure 1-4: Cleaving graphite
Other samples

You can mount other samples on the spare disc shaped sample supports (Figure 1-2: Contents of the tool set (page 15), item 7). The supports are made of a magnetic steel that is galvanically coated with nickel. Use conducting glue to attach the sample to the sample support. Contact Nanoscience Instruments if you have difficulties obtaining such a glue.

1.4.3: Mounting a sample

To mount a sample onto the sample holder:

1. Unpack the sample holder (Figure 1-2: Contents of the tool set (page 15), item 5) from its plastic storage vial, touching only its black plastic handle.

**IMPORTANT**

Always store the sample holder in its plastic storage vial in order to prevent corrosion (see Chapter 16: Maintenance (page 197)).

2. Put the prepared sample onto the magnetic end of the sample holder using a pair of tweezers (Figure 1-5: Putting the sample on the sample holder).

![Figure 1-5: Putting the sample on the sample holder](image)

3. Lower the front end of the sample holder onto the sample holder guide spheres (two metal balls on the bottom inside of the scan head) first. Then gently settle the back end onto the approach motor support.

Place the sample holder into the scan head carefully so that it does not touch the tip, and in such a way that the sample is not pulled from the sample holder by the magnet that pulls the sample holder down onto the approach motor (Figure 1-6: Placing the Sample Holder in the scan head).
Figure 1-6: Placing the Sample Holder in the scan head
CHAPTER 2:
First Measurements
2.1: Introduction

In this chapter, step-by-step instructions are given to operate the microscope and to perform simple measurements. More detailed explanations of the software and of the system can be found elsewhere in this manual. If you are not familiar with the traxSTM control software, first read Chapter 7: The user interface (page 61) and the chapters directly thereafter, or try using the traxSTM control software in microscope simulation mode (see Section 2.7: Running the microscope simulation).

The traxSTM Control Software provides all functions to operate the microscope during imaging of surfaces and more advanced operating modes. It also provides data analysis functions for post-processing of measurement data.

The main control software window (also referred to as workspace) consists of five major areas:

1. The Measurement pane on the left. This area contains the so-called Operating Windows, which are used to acquire and display ongoing measurement data.
2. The Document Space in the middle. This area is used for displaying and analyzing previously stored measurement documents.
3. The Info pane on the right. This area contains several stacked Panels and is used to group a diverse array of functionality and information.
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4. The Ribbon at the top. This area is used to access all action functions.
5. The Status Bar at the bottom. This area is used to display additional information.

Help

The Help Panel provides quick access to PDF versions of the user manuals belonging to your system, to relevant application notes and technical notes, and to online sources of information (direct links to the Nanoscience Instruments website).

Go to View >> Help to open this window.

2.1.1: Entering and changing parameter values

When using the Nanoscience Instruments traxSTM and the traxSTM control software, you may from time to time need to change or enter parameter values. These can be found in the parameter sections of the Operating windows and in various dialogs.

To change a parameter or enter a value:

1. Activate the parameter by clicking inside the (white) parameter edit box with the mouse:

2. In case of a drop-down menu selection list, change the selection using the mouse or the up and down arrows on the keyboard. In case of a numerical value, use one of the following methods:
   - Use the up and down arrow keys on the keyboard to increase or decrease its value. The new value is automatically used after one second.
   - Click the arrow buttons $\pm$ next to the parameter value with the mouse pointer.
Normally, the parameter value is changed by a small amount (usually in the range of 1–10%). Some edit boxes are doubling or dividing the parameter value by two (e.g. the “points/line” parameter). The new value is automatically used after one second.

- Enter the new value using the keyboard. The entered value is applied upon pressing the “Enter” or “Return” key, or by activating another input. The entered value is discarded upon pressing the “Esc” key. The unit prefix can be changed by typing one of the following keyboard keys:

  - f = femto, space bar = no prefix
  - p = pico, k = kilo
  - n = nano, M (shift-m) = mega
  - u = micro, G (shift-g) = giga
  - m = milli, T (shift-t) = tera

Examples: if the basic unit is Volts, type “m” to change to millivolts, type the space bar for volts, type “u” for microvolts.

Sometimes the program will change an entered value to a slightly different value. This happens when the desired value is outside the digitization range of the traxSTM controller, for example due to resolution or timing limits. In such cases, the desired value is automatically changed to the nearest possible value.

### 2.2: Preparing the instrument

Prepare the instrument as follows (see Chapter 1: Preparing for measurement (page 4) for more detailed instructions):

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

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

- Open the menu item “File” >> “Parameters” >> “Load...” and load the file “Default_STM.par” from the directory that holds the default traxSTM configurations. Usually this is “C:\Program Files\Nanoscience Instruments traxSTM\Config”.

### 2.3: Approaching the sample to the tip

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 motor, and the Automatic final approach. The color of the Status light in the traxSTM control software shows the current status of the approach:


**Approaching the Sample to the Tip**

- **Orange/yellow**
  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 and you will have to prepare and install a new tip again.

- **Green**
  The approach has finished successfully: the Z-scanner is within the measuring range.

To prepare for the approach process:

- Select the Acquisition tab
  The controls for positioning the sample with respect to the tip are located in the Approach group.

### 2.3.1: Manual Coarse Approach

To perform a manual coarse approach:

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

![Figure 2-2: Manual Coarse approach](image)

2. 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.

3. Put the magnifying cover (Figure 1-1: Components (page 14), item 2) over the scan head without touching the sample holder.
4 Place the magnifier in such a way 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.

**2.3.2: Manual approach using the approach motor**

In this step, the sample surface is brought as close to the tip as possible, without touching it. The closer the two are together, the less time the automatic final approach takes.

1 Watch the distance between tip and sample with help of the magnifier.

2 Click the “Advance” button in the Approach group of the Acquisition tab to move the sample to within a fraction of a millimeter of the tip:

You should only just be able to see the gap between the tip and its mirror image (*Figure 2-3: Tip–sample position*). The smallest visible gap depends on the observation angle of the magnifier and the illumination of the sample.

*Figure 2-3: Tip–sample position.* Position at the end of the Manual approach with the approach motor.

3 If you cannot see the motor moving, clean the sample holder guide spheres and the surfaces of the approach motor following the procedure described in *Chapter 16: Maintenance* (page 197) of the manual.
2.3.3: Automatic final approach

In this last step, the sample automatically approaches the tip until a given Setpoint is reached. First check that the Setpoint and the feedback speed are set properly. The easiest way to do this is to use the Imaging Wizard:

1. In the Preparation group of the Acquisition tab, click the “Wizard” button:

2. Select "Imaging..." from the drop-down selection menu. A dialog will pop up, which will ask you some basic questions about your sample and your measurement needs.

3. Answer the questions of the wizard to the best of your knowledge. For descriptions of the features of standard Nanoscience Instruments samples refer to Section 3.4.2: Nanoscience Instruments samples (page 27) of the manual.

Now that the initial software settings have been given suitable values, you need to name the measurement series (see Section 13.4.1: History File mask (page 156)). Each completed measurement (scan/image) will be temporarily saved (automatically) in the History folder under this name, with index numbers (or, optionally, date and time attributes) added to identify the individual measurements. It is best to enter the measurement series' name now, since the control software will (by default) start measuring as soon as the final approach is done. It is also strongly recommended to move all relevant measurements to a new folder when you are finished, since the files in the History folder will be overwritten over time (see Max History Files (page 183)).

To set the measurement series name:

1. Activate the Gallery panel (see Section 13.4: Gallery panel (page 155) of the manual) in the Info pane.

2. Click the History tab at the top of the Gallery panel with the mouse.

3. In the entry box at the top of the panel, enter a name by hand or use the Mask Editor dialog (see Section 13.4.4: Mask Editor dialog (page 157) of the manual) to create the name mask.

If no [INDEX] attribute is explicitly added to the name mask, it will be automatically applied to the end of the file name so that individual measurements can be stored and distinguished.
The automated final approach can now be started. To do this:

1. In the Approach group of the Acquisition tab, click the “Approach” button:

   ![Approach button](image)

   The sample holder is now moved towards the tip by the approach 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 Setpoint 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 in the traxSTM control software will blink red–green–orange/yellow in cycles (see Section 7.7: Status bar (page 70)). When the approach has finished successfully, the probe status light changes from a blinking state to a constant green, and the message box “Approach done” appears:

   ![Approach done](image)

2. Click the “OK” button.

   If the approach has not finished after 10–20 seconds, try to decrease the tip–sample distance a little more using manual operation of the approach motor.

   If the automatic final approach never works, refer to Section 17.3: STM measurement problems (page 205) for the next steps to take.

**2.4: Starting a measurement**

Now that the tunneling current defined by Setpoint is flowing between tip and sample measurements can start. By default, the control software is set to automatically start measuring after the automatic approach. If this is not the case:

- Start measurements manually by clicking the “Start” button in the Imaging group of the Acquisition tab:
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 2-4: 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.

A “nervous” line in the Line graph indicates a bad tunneling contact (Figure 2-4: 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:

1. Click the “Stop” button in the Imaging group of the Acquisition tab:

   ![Stop button](image)

2. Follow the instructions in Section 17.3: STM measurement problems (page 205).

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

![Good and nervous Line graphs](image)

**Figure 2-4: Starting image.** (Left) A good Line graph. (Right) A “nervous” Line graph.

## 2.5: Achieving atomic resolution

### 2.5.1: General instructions

Once the Topography in the Line graph is reproducing stably, the scan range has to be decreased in order to observe atomic structures.

**IMPORTANT**

Measurements on the micrometer/nanometer scale are very sensitive to environment influences. Temperatures near the scan head can influence and disturb the measurement. It is best to let a promising measurement run for some time in order to stabilize thermally.
To decrease the Imaging area:

1. Click the Color map chart to make it active.
   A blue square is now drawn around the Color map chart.

2. Click the “Zoom” button in the Chart bar:
   ![Image](image.png)
   The mouse pointer becomes a pen when moving over the selected chart.

3. Move the mouse cursor to a “flat” region (showing a uniform color distrubtion) in the Color map and click on it.
   The software will now draw a square that indicates the new scan range. The size of the new scan range is displayed in the Tool Results Panel (see Figure 2-5: Zooming). If no flat region is available, refer to Chapter 5: Improving measurement quality (page 45) for further instructions.

4. Change the size of the new scan range to about 30–50 nm by clicking and dragging a corner of the square with the mouse cursor.

5. Double click the chart when the scan new area is set to your liking. You can abort the zoom function by clicking with the right mouse button.
   When you accept the new scan area, the new imaging settings are set to correspond to the area that was indicated by the square.

6. Let the Topography reproduce stably again.
To achieve atomic resolution, 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 recognized at an image size of about 4 nm. Therefore:

- Set the Image size in the Imaging panel to 4 nm.

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 the Z-Controller. Try varying all of the above parameters to get a good image (such as the one in Figure 2-6: A successful graphite measurement).

When you're satisfied with the image quality obtained, you may want to save the measurement. Refer to Section 2.6: Storing the measurement (page 22) for details on how to do this.

**2.5.2: The graphite surface**

In a good color map chart of graphite you will see a pattern consisting of bright, intermediate, and dark 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 (Figure 2-7: The graphite surface (page 22)) one can see that there are two different positions of the carbon atoms in the graphite crystal lattice: one with a neighboring atom in the plane below (gray) and one without a neighbor in the lattice below (white). As a consequence, the electrical conductivity of the graphite surface slightly varies locally, so that the atoms without neighbors appear higher than the others.

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

2.6: Storing the measurement

By default, each completed measurement is temporarily stored (automatically) on your computer so that it can be used later. Additionally, you can also take snapshots of measurements still in progress. To do this:

- Click the “Capture” button in the Chart bar:

The current measurement is immediately stored and will show up in the History page of the Gallery panel, together with all other finished/stored measurements (see Section 13.4: Gallery panel (page 155) for details). In addition, the captured document will remain open in the Document space of the traxSTM Control Software.

Measurement documents in the temporary History folder should always be moved to a new location for permanent storage when you are done measuring. For details on how to do this, see Save as (page 156). Measurement documents thus permanently stored can always be loaded with the traxSTM Control Software.
The traxSTM Control Software can be started without having the microscope connected to your computer in order to explore the traxSTM system (measurements and software) without danger of damaging the instrument or the STM tip. In simulation mode, most functions of the real microscope are emulated. The sample is replaced by a mathematical description of a surface.

When the traxSTM Control Software is started without a microscope connected to your computer, the following dialog appears:

- Click “OK”.
  The status bar will now display the text “Simulation”.

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

- In the Hardware group of the Settings tab, click the “Simulation” button.
  The “Simulation” button will now be highlighted and the status bar will display the text “Simulation”.

To exit the microscope Simulation mode:

- In the Hardware group of the Settings tab, click the “Simulation” button again.
  The highlighting of the “Simulation” button will now disappear, and the status bar will display the text “Online”.

### 2.8: Further options

From this point on, there are several things that can be done. Please refer to the respective chapters for detailed instructions:

- Performing a new measurement on another sample by repeating the instructions given in this Quick Reference Guide with the new sample.
- Improving measurement quality, as described in Chapter 5: Improving measurement quality (page 45).
FURTHER OPTIONS

- Performing a different type of measurement by choosing a different operating mode, as described in *Chapter 8: Operating modes* (page 75).
- Finishing measurements, turning off the instrument, and/or storing the instrument, as described in *Chapter 6: Finishing measurements* (page 55).