Scanning tunneling microscopy
Scanning tunneling spectroscopy

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Introduction

The aim of the practical is to give to the student an experience in operating STM apparatus, preparing the surface sample and tip, measuring the topography of the surface at different scales and studying spectroscopies using different modes.

1 Preparing the surface and the tip

1.1 The sample

The sample studied is a highly oriented pyrolitic graphite (HOPG) single crystal that has a semi-metal behaviour. Sample preparation and installation are described in the Operating Instructions manual p26.

1.2 The tip

A Pt-Ir wire is used to prepare the tip, the tip preparation is described p23 in the Operating Instructions manual. Ask the instructor to install the tip. The tip being very crucial in STM, do not hesitate to change it if you get noisy signal when scanning.

2 First measurements

2.1 Approaching the sample

The sample is approached to the tip in three steps :

1. manual course approach, see p32 in the Operating Instructions manual
2. piezo motor course approach, see p33 in the Operating Instructions manual
3. automatic piezo motor course approach, see p33 in the Operating Instructions manual

For the automatic approach, check that the set points for voltage and current are the one given p34 in the Operating Instructions manual

2.2 Large areas

Start with a large scanning area of 500 nm using a large time/line of 0.5 s/line or larger, you should be able to see a topographic image close to the one presenting p36 in the Operating Instructions manual. If the topography is does not look at all to the picture p36, one solution can be stopping the scanning process, withdrawing and retracting the sample with the piezo

motor, then retract the sample by hand and rotate the sample holder in order to probe another area. Re-do the approach steps.

When a large area looking like p36 is observed do the following :

1. In "Imaging Modes" choose "forward" and record topography and current image
2. In "Imaging Modes" choose "backward" and record topography and current image
3. Describe the topography and current image and explain the difference observed in the current image
4. Evaluate the height of a step between two terraces and try to evaluate the number of graphite planes

3 Atomic resolution

To achieve atomic resolution, follow the procedure described p35 in the Operating Instructions manual, keep the size of the image between 4-5 nm. Describe your difficulties.

3.1 Feedback loop

Record several images (topography and current) while varying the proportional and integral gain. Evidence the different working regimes in the current constant mode in the same image. Explain the differences observed between the topography and current image. Record an image in constant height mode (feedback loop open).

3.2 Drift

Find the parameters that can reduce the drift during the scan. Illustrate it with images recorded with different parameters.

3.3 Structural analysis

Using the optimized parameters (feedback, drift, set points...) record a topographic image with atomic resolution. Use the software WSXM (freeware www.nanotec.es) to exploit the recorded images. Use the line profile to estimate the lattice parameter in the 3 equivalent directions and find the direction that give access to the interatomic distance and comment. Record the FFT of the topography and comment, filter the scanning lines.

4 Spectroscopy

The spectroscopic modes are described in the Software Reference Manual p46.

4.1 Density of state

Use the modulated output as Tip Voltage from -1 V to 1 V and record the curve I vs V. Describe your difficulties. Use a scientific software (Igor, Origin, Kaleidagraph...) to derive the current curve, comment your results.

4.2 Work function

Use the modulated output as Z-axis from -3 nm to 1 nm, minus means far from the sample, plus means close to the surface. A maximum current is set in the dialog box "Input range check" to prevent from tip crash on the surface. Set Max Input to 100 nA and Min Input to 1 pA. Record a sequence of 4 averages with a nice curvature and plot the results in a scientific software. Evaluate the work function for the graphite in the air (you can use a fitting program using an exponential curve to reproduce the experimental data), comment your results.

5 Report

The report must include an introduction, the manipulations and measurements you have done, comments for each figures you present, explanations for your observations, your difficulties during the experiment, a conclusion. The length must not exceed 10 pages. One report per person must to be sent within 15 days after the practical.