MEASUREMENT OF GRAPHITE LATTICE USING STM

References:
1. Nanosurf, “Operating Instruction easyScan 2 STM”

Summary:
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 micro-copy technique works without focusing elements and features atomic resolution (laterally and vertically) (1).

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’.

This experiment learns about fundamentals of STM, procedure of the STM experiment and analysis of STM data. In particular, the experiment measures the lattice constants of graphite using STM.

Introduction and theory:
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 a STM system, a sharp 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 nano-meter (1nm= 1 / 1 000 000 000 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~0.1V) a very small tunneling current (I~1nA) 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.

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.

**Equipment:**
Nanosurf, easyScan 2 STM

**Procedure:**
*The experiment is performed using Nanosurf easyScan 2 STM. The manual is available in the lab. In particular, read the chapters including, The easy scan 2 STM, Preparing for measurement, First Measurement and STM theory to be familiar with the instrument. The expected STM image is shown below.*