Atomic Force Microscopy – Instruction Notes

Keywords: van der Waals forces, cantilever with tip, piezoelectric effect, static and dynamic modes

I. GOALS OF THE EXPERIMENT

Atomic force microscopy (AFM) plays a central role in the investigation of the structural and mechanical properties of materials. Despite the simplicity of its design, learning to use the AFM technique can be challenging. The purpose of this experiment is to familiarize the student with modern mesoscale and nanoscale imaging techniques used in condensed matter physics or biophysics. As the feature sizes of the objects of study become smaller, optical techniques become unable to resolve these features. While electron microscopes can have the required resolution, they do not provide height information. AFM technology has become the standard methods used in probing atomic, molecular and domain features, with resolutions reaching down to a few angstroms in the most advancedinstruments.

II. LEARNING CONTENT

- principles of the AFM technique and instrumentation
- tip – sample interactions
- the operational modes of AFM technique and their application ranges
- image processing with AFM technique

III. PROCEDURE

Attention: Exchange the tip only under the supervision of the advisor. Never touch the tip, the cantilever or the samples with bare hands.

FIRST LAB SESSION

1) Measurements in static (contact) mode

The most common configuration of this mode is the static force mode. In this mode, the deflection of the cantilever caused by the tip –surface interaction is kept constant by the feedback control.

1.1 Optimization measurements

The aim of these measurements is to get familiarized with the Nanosurf NaioAFM equipment and to optimize the scan and feedback control parameters (PID). For this purpose, a silicon grid (HS-100MG) with known structure array is used. The instructor will explain you the AFM software and the measurement procedure. The Gwyddion software is used to analyze the raw data and obtain the image: http://gwyddion.net.

1.2 Sample measurements

Use the optimized or slightly modified parameters and Gwyddion software to obtain the images and determine the feature sizes of four samples provided by the instructor.

SECOND LAB SESSION

2) Measurements in dynamic mode

The most common configuration of this mode is the tapping mode. In this mode, the cantilever is excited to an oscillation at or near its resonance frequency. Before starting the measurement, the contact mode - tip should be replaced with the tip suitable for tapping mode.

2.1 Optimization measurements

After finding the free resonance frequency of the cantilever the same silicon grid is used to optimize the scan and control parameters.

2.2 Sample measurements

Use the optimized or slightly modified parameters and Gwyddion software to obtain the images and determine the feature sizes of the same samples provided by the instructor.

IV. REFERENCES:

(1) Binnig, G.; Quate, C.F.; Gerber, Ch. (1986), Atomic Force Microscope, *Phys. Rev. Letters*, 56, 930-933

(2) Cappella, B.; Dietler,G. (1999), Force-distance curves by atomic force microscopy, *Surface Science Reports* 34, 1-104

(3) Bhushan, B. (2007), Scanning Probe Microscopy – Principle of Operation, Instrumentation, and Probes, *Handbook of Nanotechnology*, Springer, 591 – 635

(4) West, P.; Starostina, N., A Guide to AFM Image Artifacts, Pacific Nanotechnology, Inc., Santa Clara