BMM 311L Biomaterials and Biomechanics Laboratory, Spring 2020

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EXPERIMENT 6: Surface Properties and Atomic Force Microscopy

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1. Scope

The aim of this experiment is to investigate the materials surfaces at the nanoscale with an atomic force microscope.

2. Introduction

Atomic force microscopy (AFM) or scanning force microscopy (SFM) is a very high-resolution type of scanning probe microscopy, with demonstrated resolution approximately fractions of a nanometer. This resolution is more than 1000 times better than the optical diffraction limit. It is a technique to obtain images and other information from a wide variety of samples, at extremely high resolution. The five essential components of an AFM are: A sharp tip mounted on a soft cantilever spring; a way of sensing the cantilever's deflection; a feedback electronic system; a display system that converts the measured data into an image; and a mechanical scanning system.

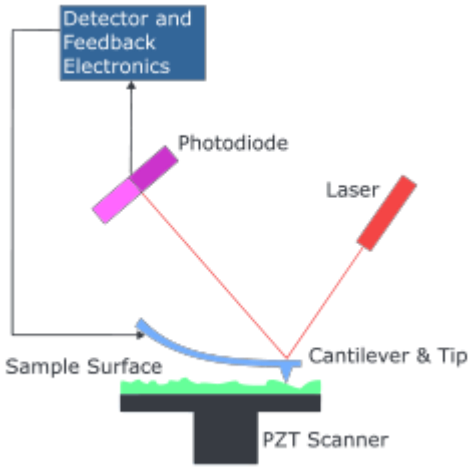

Figure 1. Schematic illustration of test specimen and 4-point bend fixture.

The tip part, which directly interacts with the sample, is mounted on the cantilever. A variety of probes has been used but the most commonly used are micro-fabricated silicon or silicon nitride cantilevers with integrated tips.

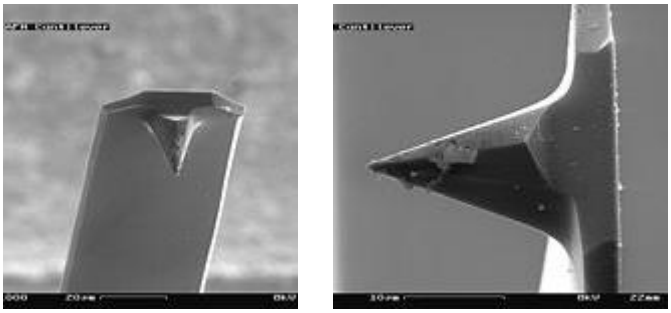

Figure 3. Electron micrograph of a used AFM cantilever.

Forces between the tip and the sample, including mechanical contact force, van der Waals forces, capillary forces, chemical bonding forces, electrostatic forces, and magnetic forces, deflect the cantilever. The cantilevers deflection is detected and converted into an electronic signal that is utilized to reconstruct an image of the surface. One of the most utilized methods to detect the cantilever deflections is the optical method: It consists in focusing a laser beam on the back of the cantilever and measuring the displacements of the reflected beam on a multiple segment photodiode. The corresponding signals are acquired and processed by a feedback electronic. The feedback system is used to control the cantilever deflection and to direct consequently the piezoelectric (for example PZT, $PbZrTiO_3$) scanner movements. Usually, the sample is mounted onto a piezoelectric translator that moves the sample in the x, y and z directions underneath the tip [1].

The AFM can be operated in a number of modes, depending on the application. In general, possible imaging modes are divided into static (also called contact) modes and a variety of dynamic (non-contact or "tapping") modes where the cantilever is vibrated.

The AFM has several advantages over the electron microscope. Unlike the electron microscope, which provides a 2-D projection or a 2-D image of a sample, the AFM provides a true 3-D surface profile.

Additionally, samples viewed by an AFM do not require any special treatment that would actually destroy the sample and prevent its reuse. While an electron microscope needs an expensive vacuum environment for proper operation, the AFM can work perfectly well in an ambient or even liquid environment [2].

3. Test Specimen and Laboratory Equipment

The test specimens are standard AFM tip, soft silicon AFM tip and other apparatus, PC12 cell line and AAO membrane. The hard AFM tip will be used for scanning iPhone camera glass and other apparatus. The soft silicon AFM tip will be used for scanning the PC12 cell line on the AAO membrane. A specific fixation protocol was used for prepare the PC12 cell line on AAO membrane.
*PC12 Cell line is derived from a pheochromocytoma of the rat adrenal medulla.
*AAO membrane: Anodized aluminum oxide membrane, a kind of biomaterial has high porosity.

4. Experiments and Procedure

At the end of this experiment different surface images will be seen the AFM microscope. Figure 3 is given below as an example image to give you an idea. After the experiment, you should measure pore diameter of AAO, PC12 cells diameter and surface area of IPhone camera segments by using Image J.

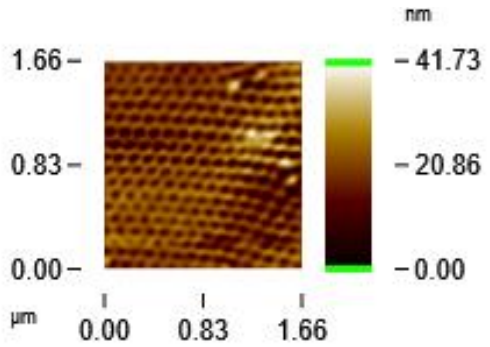

Figure 3. The AFM microscope image of an AAO membrane.

References

[1] Experiment Nr.42 Notes, Atomic Force Microscopy, Exploring the molecular scale in real space.

[2] Capella, B., Dietler, G. 1999. Force-distance curves by atomic force microscopy, Surface Science Reports.

Safety in Laboratory

1. Eye protection must be worn during the tensile test.
2. Wait for the Teaching Assistant before beginning the laboratory exercise so that they can guide you through testing your first sample.
3. Before beginning a test or moving/resetting the universal testing machine, make sure all items including hands, hair, etc. are clear of the machine.

Grading

Lab reports: (70%)*
Short exam at end of 3rd and 6th experiments: (30%)
* Late delivered reports will lead to lose of 10 points/day.
* Each group delivers one report.

Labs

TOBB ETÜ Technology Center, B06 (Experiments 1-4), 201 (Experiments 5), 206 (Experiment 6).

Contacts

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