Pre-Lab: Atomic Force Microscopy (AFM)

Please note that this experiment is NOT in the P. Chem lab in Mergenthaler. Students doing this experiment should go directly to Dunning Hall 14.

NOTE: Each student should bring a 3.5" floppy disk to save and take data.

This experiment is designed to use an AFM to image a number of different surfaces. This experiment also incorporates a specific web-based module designed to help students come to grips with the underlying physical nature of AFM. The web-site can found by accessing my homepage at: http://www.jhu.edu/~chem/fairbr/index.html and then clicking on *Teaching* followed by *Web-Based Modules for Physical Chemistry Lab Experiments* and going to *Atomic Force Microscopy*.

Because AFM is a very modern instrumental technique that is highly visual there are a wide range of excellent websites that can help you understand the concepts behind an AFM as well as its wide ranging applications in both academic and industrial settings. For example,
http://stm2.nrl.navy.mil/how-afm/how-afm.html
is an excellent website on AFM.
In fact by simply typing either atomic force microscopy or AFM in your favorite browser you should be able to access dozens of AFM sites that can be of assistance. It is strongly recommended that you use some of these websites to familiarize yourself with the basic working of an AFM.

The AFM lab consists of three separate imaging experiments:

(1) Imaging a diffraction grating.
(2) Imaging a ceramic surface.
(3) Nanomechanical measurements on different materials using contact mode AFM

Details of experiments (2) and (3) can be found as separate pdf attachments

To make sure that you understand these experiments please answer the following questions in the prelab.

Experiment 1: Imaging a diffraction grating.

(a) What is a diffraction grating?
(b) The diffraction grating is really used as a form of calibration for the AFM – based on the nature of a diffraction grating can you explain this?

Experiment 2: Imaging a ceramic surface

(a) Other than Al_2O_3 can you give the chemical formulae for two other ceramic materials?
(b) Why are ceramics good insulators and metals good conductors?
(c) What is a grain size? (You may need to look up a basic book on solid state or materials science or the web for this)
(d) **Bonus Question**: One of the properties of ceramic materials, piezoelectricity is actually an integral and very important part of an AFM. Can you explain how piezoelectricity is used in AFM imaging and why?

Experiment 3: Nanomechanical Measurements on Different Materials Using Contact Mode AFM

Figure 1 is a typical AFM force curve, showing the force on the tip as a function of sample-tip separation; copy it in your answer sheet.

(a) What are Van der Waals forces?
(b) Can you identify another long-range force that would be acting on the tip in ambient conditions? (Hint: moisture)
(c) Identify on your graph the attractive and repulsive regimes.
(d) Can you identify the problems with imaging very soft materials using contact mode AFM.

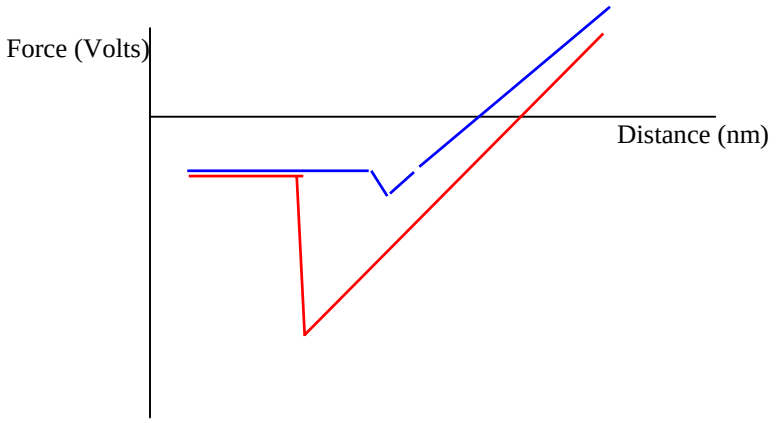

Figure 1: A typical force curve illustrating the force on the tip as a function of sample-tip separation.

(e) Define the equation that summarizes Hooke's law.
(f) Can you explain using a molecular level explanation (form a force distance curve) the origin of the Hooke's law for small extension?
(g) What physical property of a material does the proportionality constant in Hooke's equation measure? How can it be calculated from force curve?