

Laboratory 7: Atomic Force Microscopy (AFM)

Lab Write Up:

The lab write up should start with answers to the following questions:

1. How does an AFM work? Please describe the basic workings of an AFM in words (and pictures if you like). In your answer you should include the following information:
 - a. What is the role of the piezoelectric material (PZT)?
 - b. What is the role of the cantilever?
 - c. What is the role of the laser?
 - d. What is the limiting factor with respect to AFM resolution?
 - e. What does the AFM measure – (a) electron density, (b) height, or (c) pressure on the surface?

2. What is the difference between contact and non-contact mode?

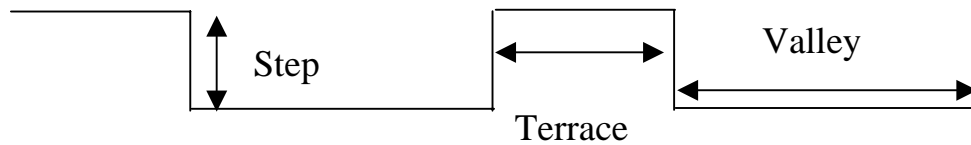
3. The equation for the resonant frequency of a spring is:

$$\text{res. freq. of spring} = 1/2\pi(\text{spring constant/mass})^{1/2}$$

The spring constant of a cantilever is relatively small. Is the resonant frequency of the cantilever high or low?

4. Describe the meniscus effect?

Experiment 1: Diffraction Grating



From the images you collected:

1. What is the average height and standard deviation of the grating steps?
2. What is the average width and standard deviation of both the terrace and valley portions of the grating?

From what you know about diffraction what region of the electromagnetic spectrum (e.g. infrared, visible) would you expect the diffraction grating to be used?

In one or two sentences describe qualitatively how a diffraction grating of known dimensions might be used to determine the radius of an AFM tip?

Experiment 2: Ceramic Surface

Using the data from all three images at x1 resolution:

1. Calculate the average number and standard deviation of the particle density per cm^2 (# particles/ cm^2)?
2. Calculate the average and standard deviation of the particle heights?
3. Why would AFM imaging of a ceramic surface be superior to other types of high resolution imaging techniques such as electron microscopy?
(hint: think about the electrical properties of the surface)

4. The heat shield tiles for the space shuttle are made of ceramic materials. What difference would you expect to find them in before and after a mission? How would AFM imaging help you in this analysis?

Experiment 3: Nanomechanical Measurements On Different Materials using Contact Mode AFM

1. Calculate the stiffness (k_s) of each sample. (units N/m)
2. Relate the stiffness results to the nature of the samples.
3. Identify the largest source of uncertainty for the calculation of k_s .