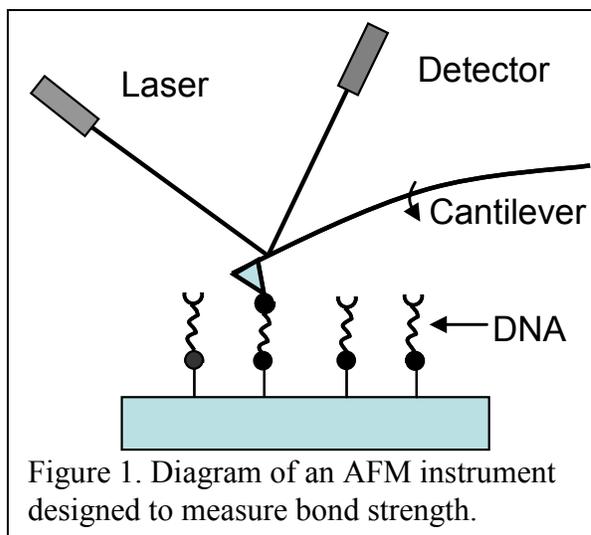


## Experiment 10: Atomic Force Microscopy

In this experiment you will learn the basics of atomic force microscopy (AFM). AFM and related Scanning Probe Microscopies (SPM) have become some of the most important new laboratory techniques for studying nanoscale phenomena on surfaces.

AFM works by scanning a sharp tip on the end of a cantilever over a surface. When the tip approaches within a height,  $z$ , the force exerted by the interactions between the tip and surface causes the AFM cantilever to flex. Depending on the cantilever stiffness, a given force will cause the cantilever to move a certain distance. The stiffness  $k$  of the cantilever determines the ratio between the distance moved and the force exerted by the surface, such that  $k = F / \Delta x$ . The cantilever deflection  $\Delta x$  is



usually measured by reflecting a laser beam off the top of the cantilever. When the cantilever deflects, the laser beam moves. The position of the laser beam is measured with a position-sensitive photodiode detector.

Each AFM cantilever has a different stiffness, or force constant. The cantilevers we will use have typical force constants of 0.2 N/m. They are also typically 2  $\mu\text{m}$  thick, 450  $\mu\text{m}$  long, and 50  $\mu\text{m}$  wide. The detector side has an aluminum coating for reflection of the detection laser beam.

### Experiment

Read the AFM manual thoroughly, and follow the instructions for setting it up and mounting the “microstructure” sample. **Be careful not to touch the samples with your fingers!** The sample should be handled and mounted using tweezers or a gloved hand. Before starting, also read the AFM software manual, which will show you how to scan using the AFM.

1. Using the EasyScan software, approach the surface of the microstructure sample **very slowly**. The most common problem with these experiments is to be impatient and smash the tip into the surface (manually), ruining our AFM tip. The tips are fairly expensive, and you should not have to change the tip during your experiment. The images should show reproducible, clear structure. If not, it is likely a problem with the tip. Follow the instructions for preparing a new tip. It may take several tries to get a good tip. Play with the controls, moving to different locations, changing the scan size, and z-range. Save images.

2. Next zoom in on a distinct sample area and try to achieve maximum resolution. This will require some patience. What is the maximum resolution that you can get with this AFM and sample?
3. Determine the width, length, and height of the pattern, with uncertainty. Save images. Comment on the accuracy of these measurements.
4. Study, then explain if possible, how image quality is affected by:
  - a. z-range
  - b. scan range
  - c. time per scan line
  - d. offset
5. Each group will be assigned one new sample to be imaged next. Ask the instructor which one you will be required to study. Image the sample and characterize it in the same way outlined above for the microstructure sample. Characterize the surface quantitatively, with uncertainties reported for each measurement.
6. In your lab writeup, present a graph showing the distance between the features on the sample. Show clearly where the graph comes from on an image. Describe your analysis and how you estimated uncertainties.