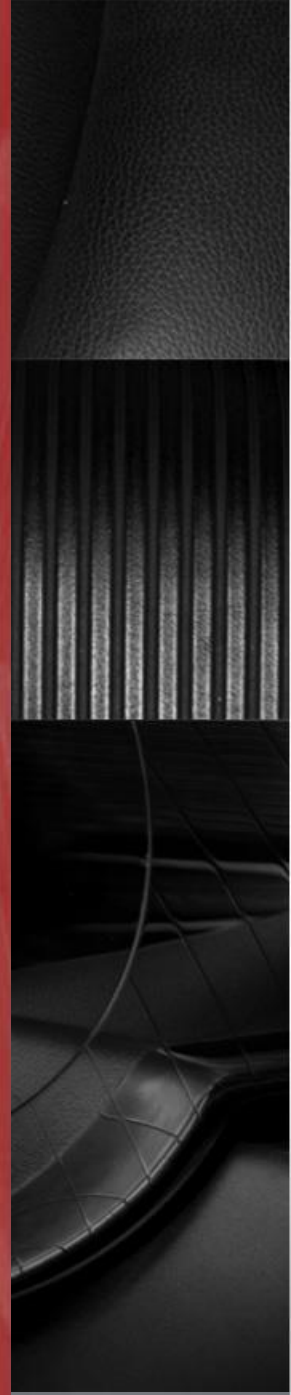
Lab 10: AFM

April 22-22

2016



Procedure

1) Understand
   - Walk-through of the system, identifying important controls & hazards
2) Calibrate
   - Generate calibration curve
3) Image samples
   - MEMS device
   - CD tracks
   - Calibration grating

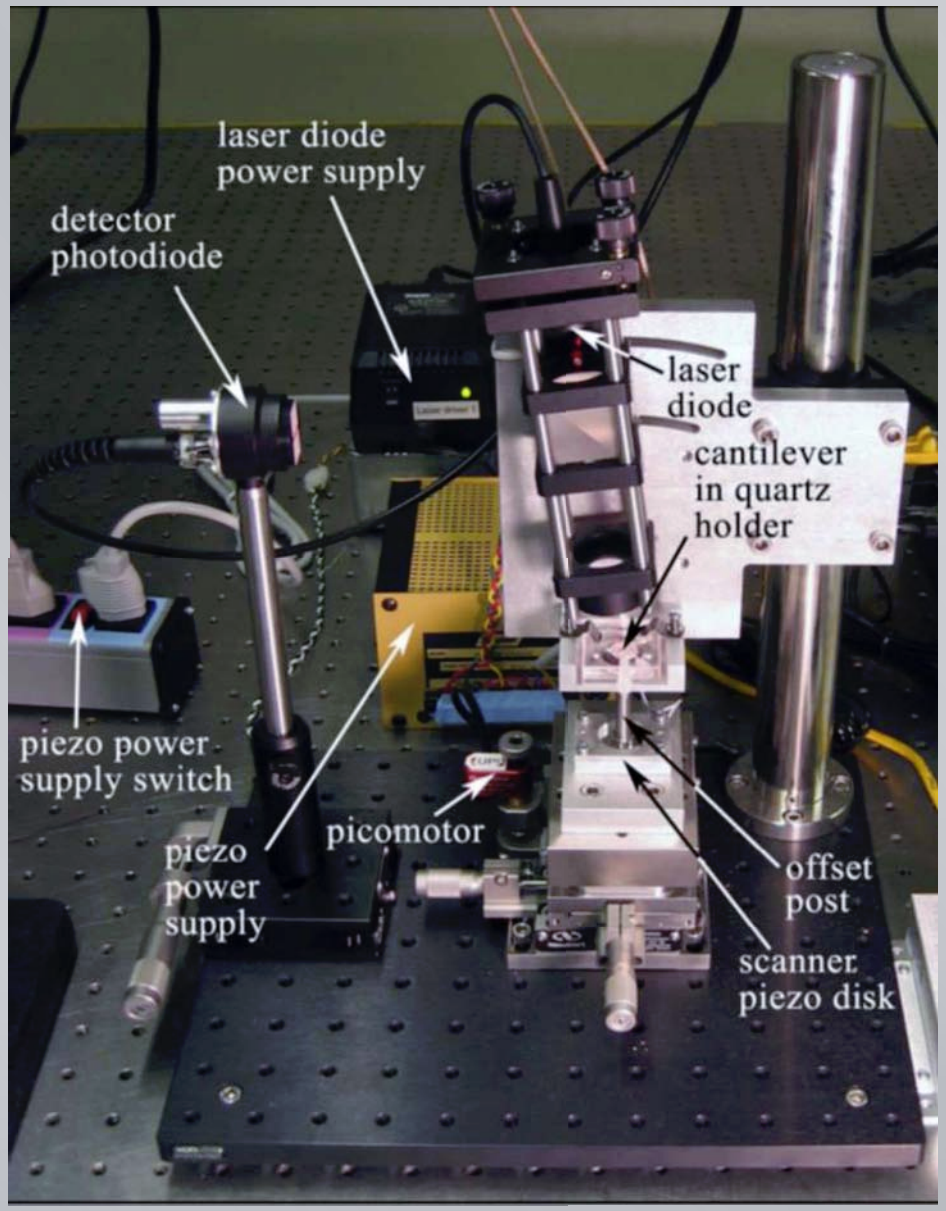


Image courtesy of Edward Boyden. Used with permission.

Our AFM Setup

- Piezo control of the sample

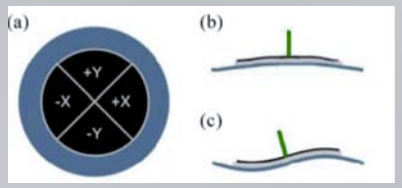


Image courtesy of Edward Boyden.
Used with permission.

- Interdigitated fingers
  - Diffraction pattern of dark & light spots called modes
  - λ = 635 nm for laser – Do not stare into the laser!

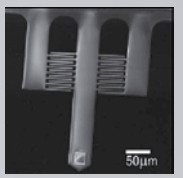


Image courtesy of Edward Boyden.
Used with permission.

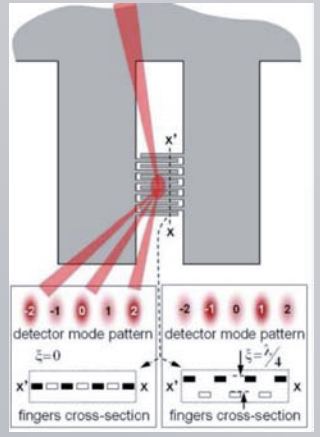


Image courtesy of Edward Boyden.
Used with permission.

- Z-mod – switch DOWN
  - Use for calibration
- Image mode – switch UP
  - Use to measure samples
- Recommend “Print Screen” for data acquisition

Calibration in Z mod

- Goal: Relate detector's voltage signal to physical tip deflection
  - nm of tip bending per volt of signal
- Find good bias point when tip touches then releases
- Mode from fully bright to dark (peak to trough on $\sin^2$ function) when fingers deflect a distance of $\lambda/4$, about 160 nm
  - Use this to quantify horizontal axis
  - Calculate slope, nm/V
- Need to correct slope as interdigitated finger is not tip deflection
  - Use equation for simple rectangular beam with applied end-load
  - $A_{corr} = 2/(3m_{id}^2-m_{id}^3)$, $m_{id}= L_{ID}/L_T$
- Once you calibrate do not move any optics!

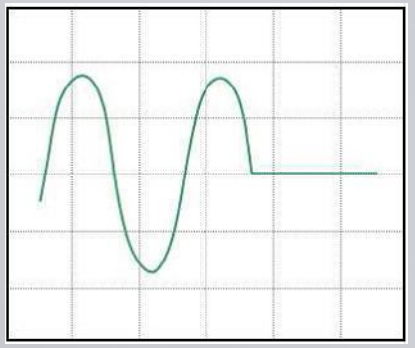


Image courtesy of Edward Boyden. Used with permission.

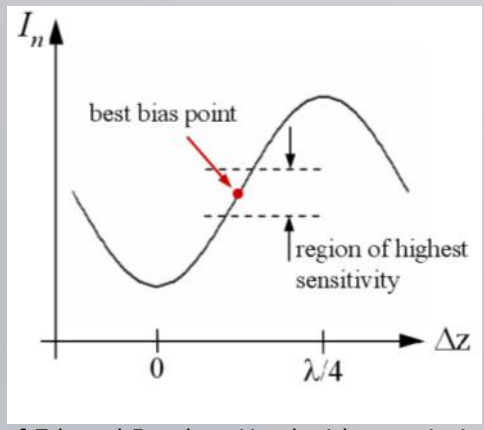


Image courtesy of Edward Boyden. Used with permission.

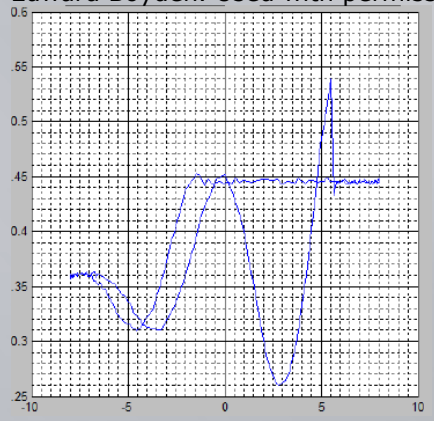


Image Mode

- Stop z-mod
- Switch sample, if needed
- Engage tip
- Start imaging!
- Capture scans to get image dimensions
- Capture scope view scans to give feature height data

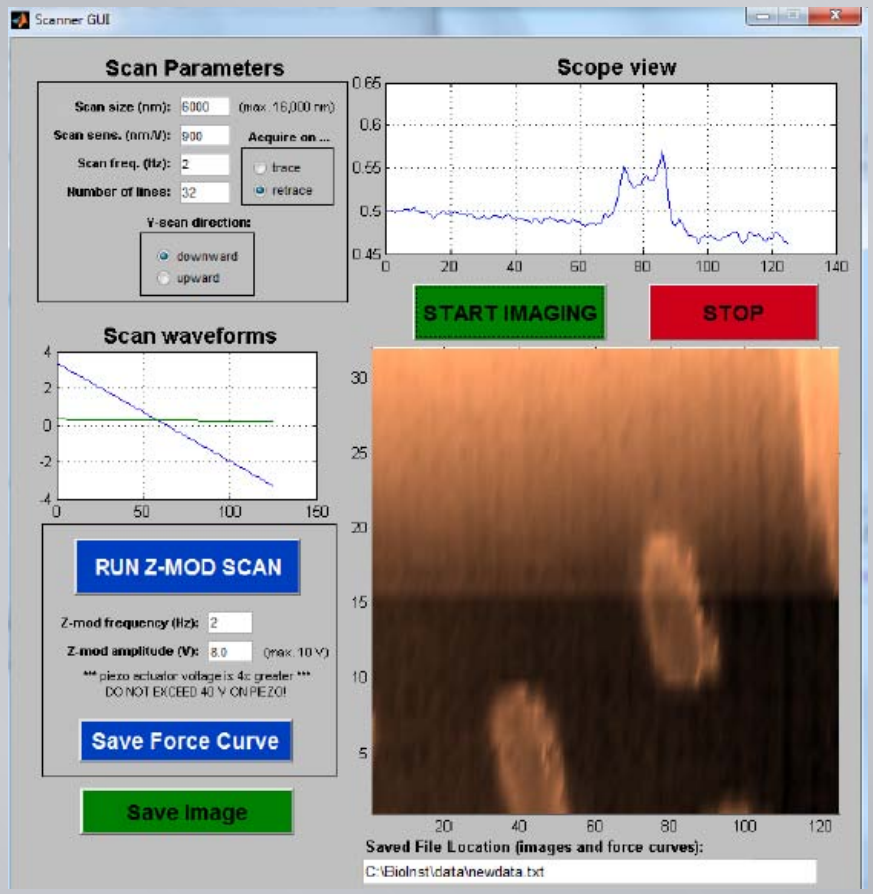


Image courtesy of Edward Boyden. Used with permission.

Thermal Noise

1) Calibrate – can use the same factor as part 1 if no changes to system
   - Calibration using bare Si wafer, run z-mod
2) Increase gain
   - Make note of gain change and adjust calibration factor
3) Measure thermal noise
   - Run Labview Spectrum Analyzer tool
   - Observe 1/f noise, thermomechanical “white” noise, and resonance peak(s)
4) Perform calculation and check values
   - Calculate Q, ratio of energy stored/energy dissipated
   - Calculate $\langle x^2 \rangle$, spectral density of cantilever deflection in flat region below resonance peak (white noise region)
   - Solve expression for k, and calculate experimental spring constant– check units and compare to given value in lab notebook
   - $Q = k/(b\omega_o)$, $\langle f_n^2 \rangle = 4k_bTb = k^2\langle x^2 \rangle$

2.674 / 2.675 Micro/Nano Engineering Laboratory

Spring 2016