Instrumentation

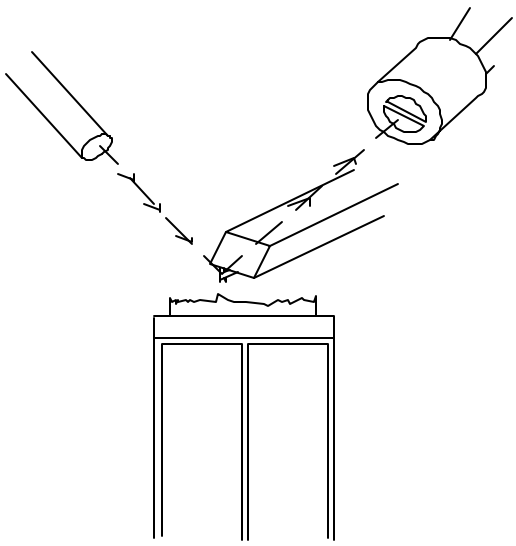
June 10, 1998

Kim Byung-Il

Dept. of Physics
Seoul National Univ.

Optical beam deflection detection Method

- Force Sensing method
  - ✧ tunneling detection
  - ✧ capacitance detection method
  - ✧ interferometry method
    - ✓ somewhat complicated
  - ✧ optical beam deflection detection method
    - ✓ most commonly used method
    - ✓ laser diode(λ=670nm)
    - ✓ bicell photodiode



● detection mechanism

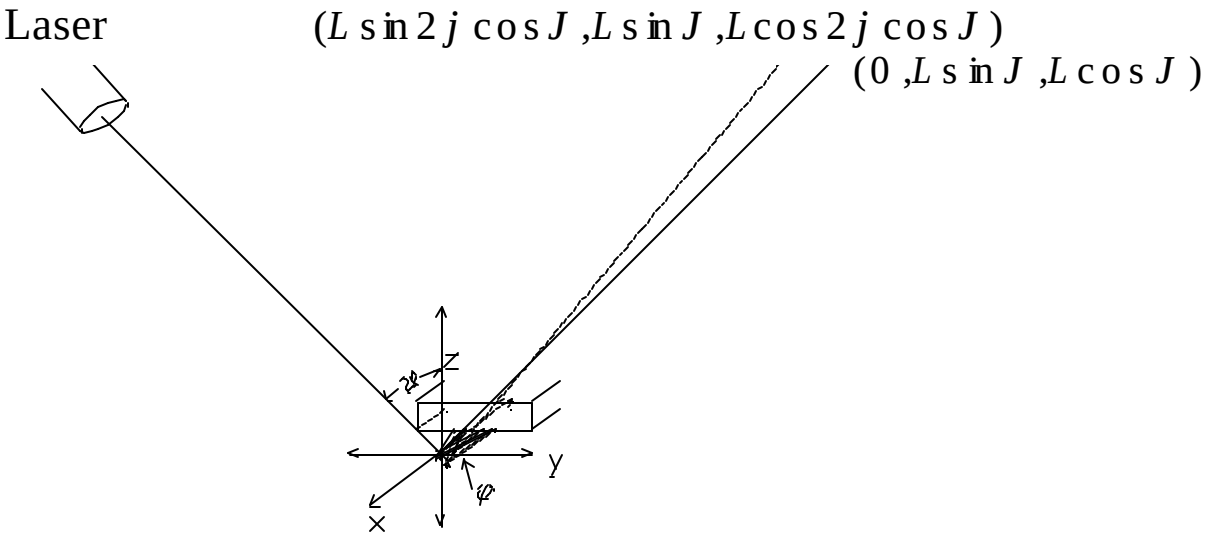
L: distance between PSD and cantilever

ϑ: incident angle with z axis in the yz plane

φ: the deflection angle of cantilever by F_{ext}

δz: change of z coordinate of cantilever by F_{ext}

λ: length of cantilever



✧the change of x, y, z on the detector

$$\Delta x \cong 2L\cos J\left(\frac{dz}{\lambda}\right)$$

$$\Delta y = 0$$

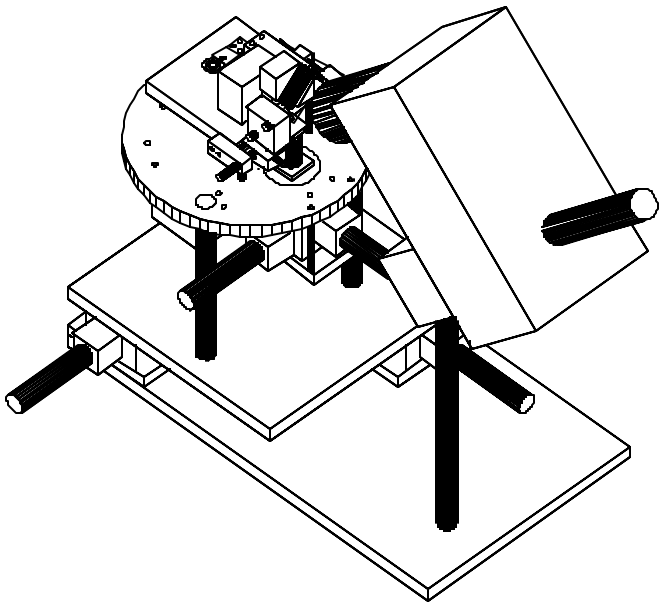
$$\Delta z \cong -2L\cos J\left(\frac{dz}{\lambda}\right)^2$$

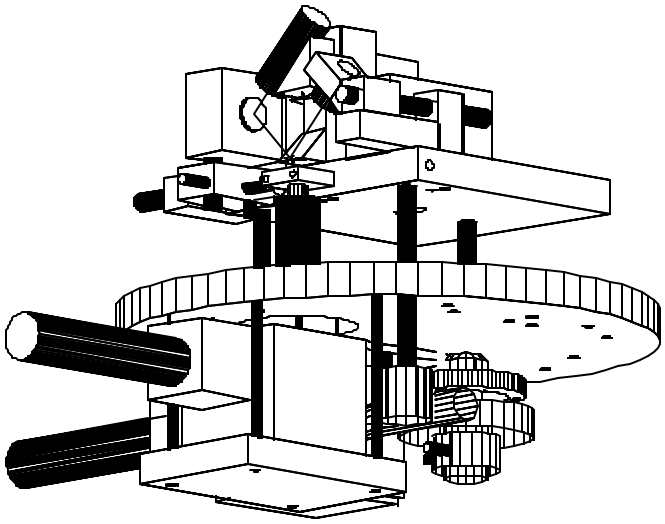
✧For $L=2cm,\ J=45°,\ l=200mm$

$$\Delta x \cong 140 dz$$

Design of Mechanical Parts

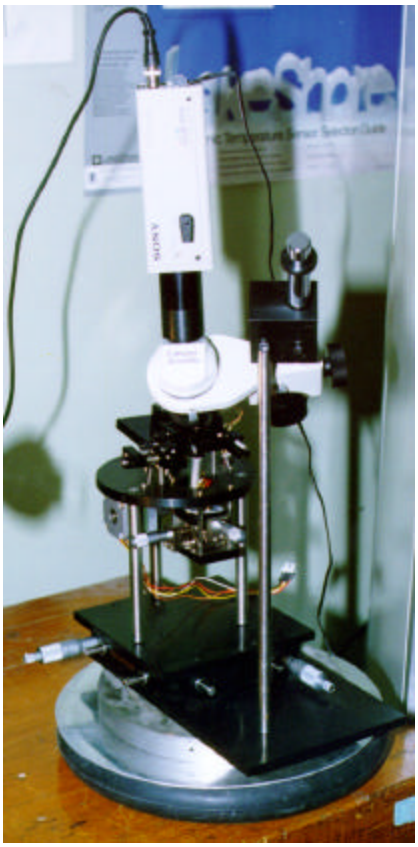
- design consideration
  - ✧rigidity and stability
    - ✓mechanically stiff and symmetric
  - ✧head
    - ✓optical beam deflection system
    - ✓metal box for preamplifier
  - ✧base
    - ✓scanner with XY-translational stage
    - ✓tip-sample approaching system
  - ✧optical microscope
    - ✓long-working-distance objective
    - ✓CCD camera with video monitor

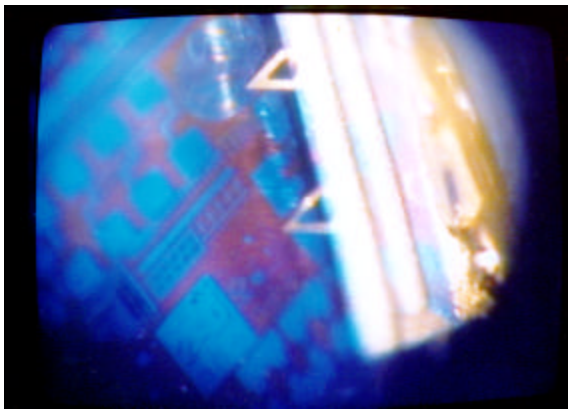




- tip-sample approaching system
  - ✧coarse approach
    - ✓two thumbscrews
  - ✧fine approach
    - ✓stepping motor(1.8°/pulse)
    - ✓micrometer (0.5mm / turn) with worm gear(1/80)
    - ✓approaching rate:40å/pulse
- scanner
  - ✧piezoelectric tube with samle holder
  - ✧XY-translational stage
  - ✧maximum scan area: 40μm×40μm
  - ✧calibration
    - ✓Michelson-Moley interferometry

Scanning Force Microscope

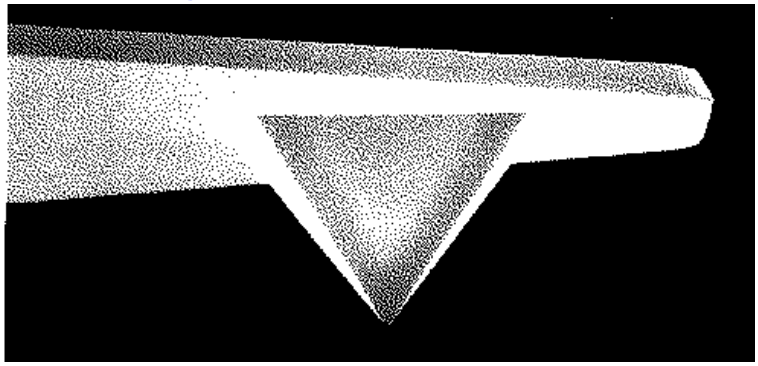




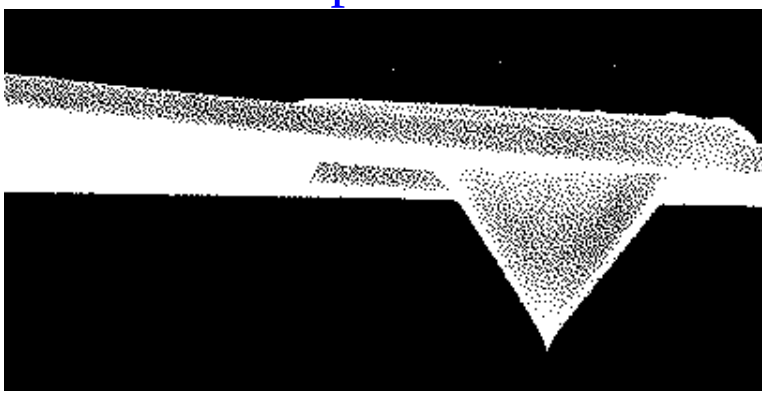
video monitor

- cantilever
  - ✧commercial cantilever with ‘V’ shape

  - ✧contact mode
    - ✓Si_3N_4, k=0.064N/m, ω_0=*17kHz*
    - ✓microlever : pyramidal tip

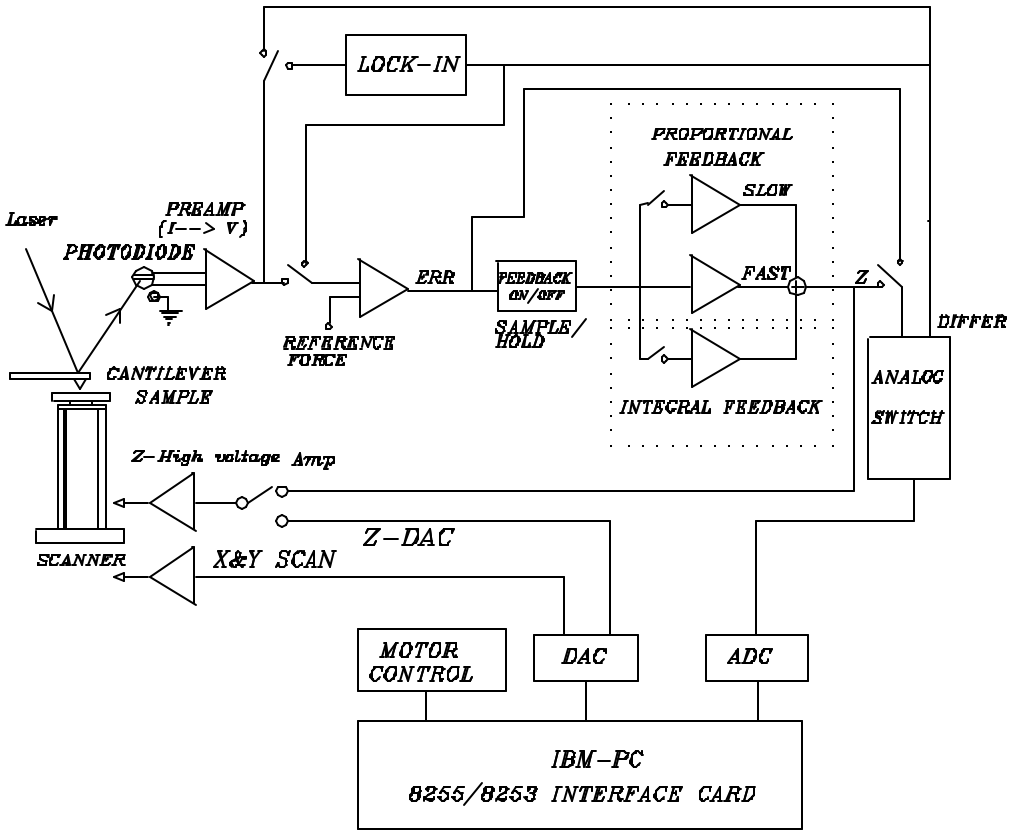


  - ✧noncontact mode
    - ✓doped Si, k=2.1N/m, ω_0=109kHz
    - ✓ultralever : conical tip



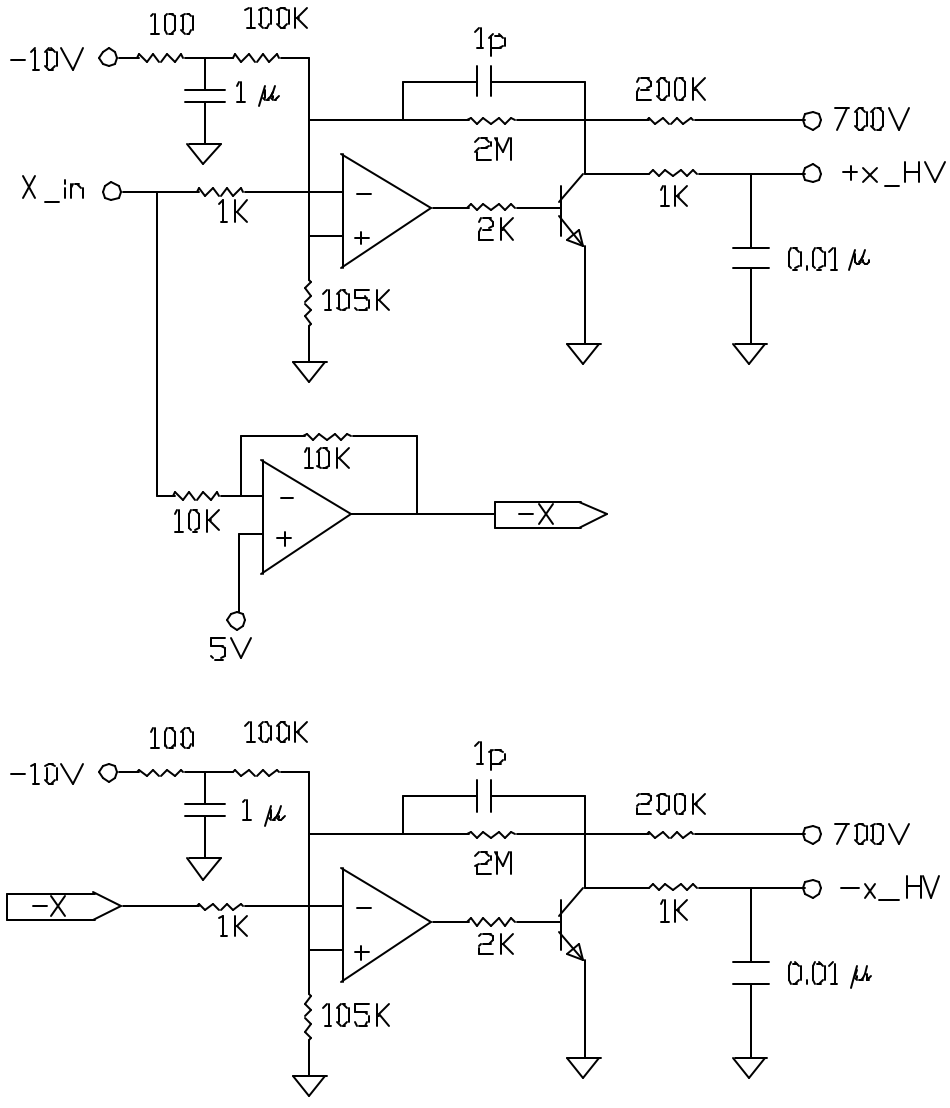
Elecronics Parts

- block diagram of SFM electronics
  - ✓ feedback circuit
  - ✓ scan size controller and PZT driver
  - ✓ stepping motor controller
  - ✓ computer interface
  - ✓ rms-to-dc converter
  - ✓ two lock-in operation

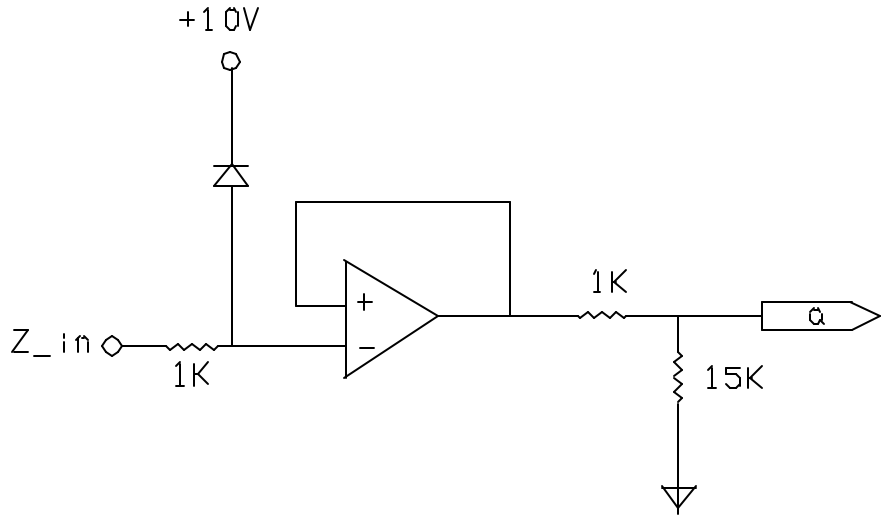


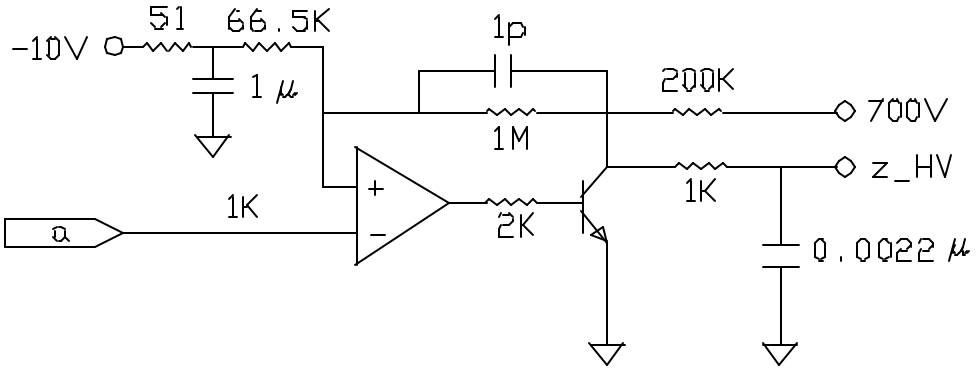
PZT tube driving circuits

- high voltage amp. for X-Y piezo
  - ✓ X_in : inputs from D/A converter via size and offset controller
  - ✓ +x_HV:200V-600V
  - ✓ -x_HV:600V-200V
  - ✓ Δx_HV:-400V - +400V

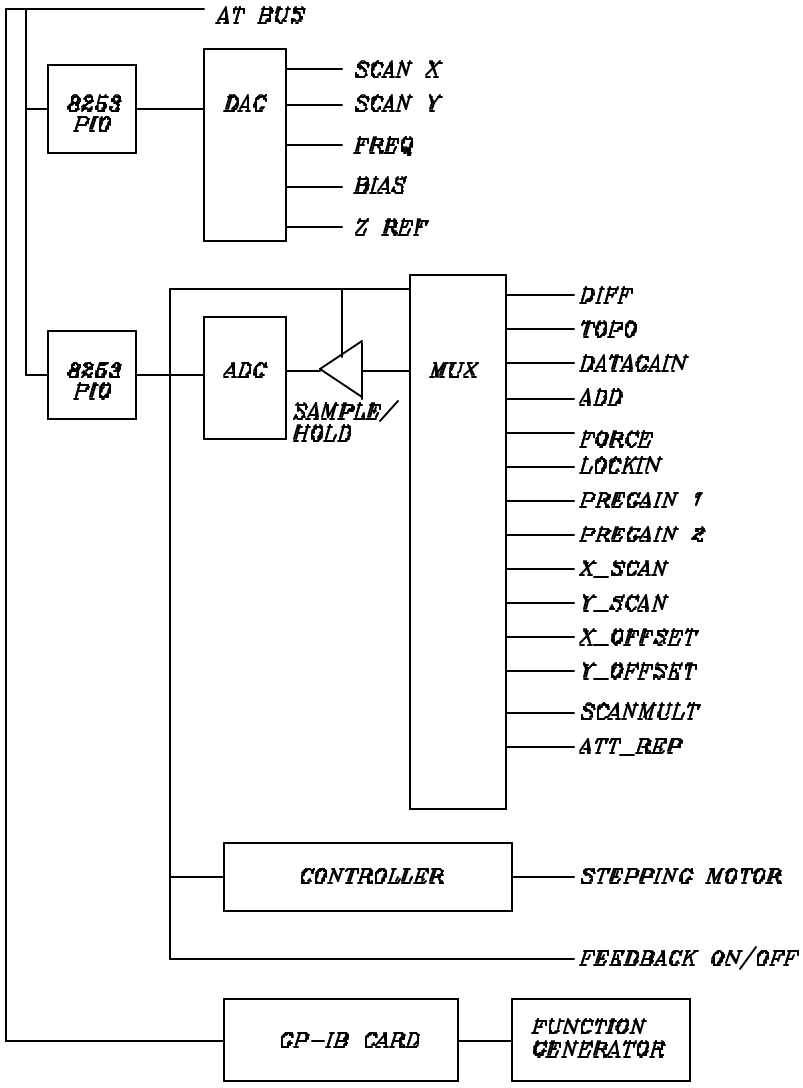


- high voltage amp. for Z-piezo
  - ✓ Z_in: feedback output, output from computer via D/A converter
  - ✓ z_HV : 0V - 300V



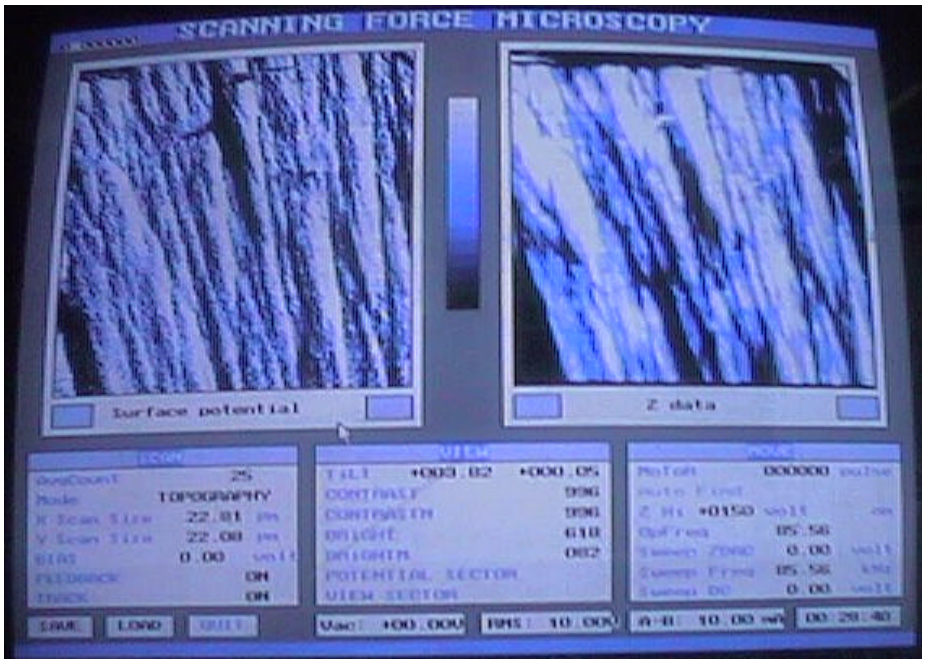


- I/O interface
  - ✧8255 PIO(programmable input/output)
  - ✧A/D converter
  - ✧multiplex(SPC 16s)
    - ✓A-B, data, set value, scan size, rms *etc*.
  - ✧D/A converter
    - ✓x scan, y scan, z reference and bias
  - ✧feedback ON/OFF
  - ✧pulse siganl for stepping motor



Software

- data acquisition
  - ✓ 256×256 pixels
  - ✓ simultaneous acquisition of two data
  - ✓ sectioning profile
  - ✓ monitoring of force and amplitude



- force spectroscopy
  - ✧ amplitude-frequency curve
    - ✓ selecting operation frequency
  - ✧ force-distance curve
    - ✓ force set in contact mode
  - ✧ amplitude-distance curve
    - ✓ selecting operation mode in ac mode
  - ✧ amplitude-bias curve
    - ✓ scanning potentiometry application