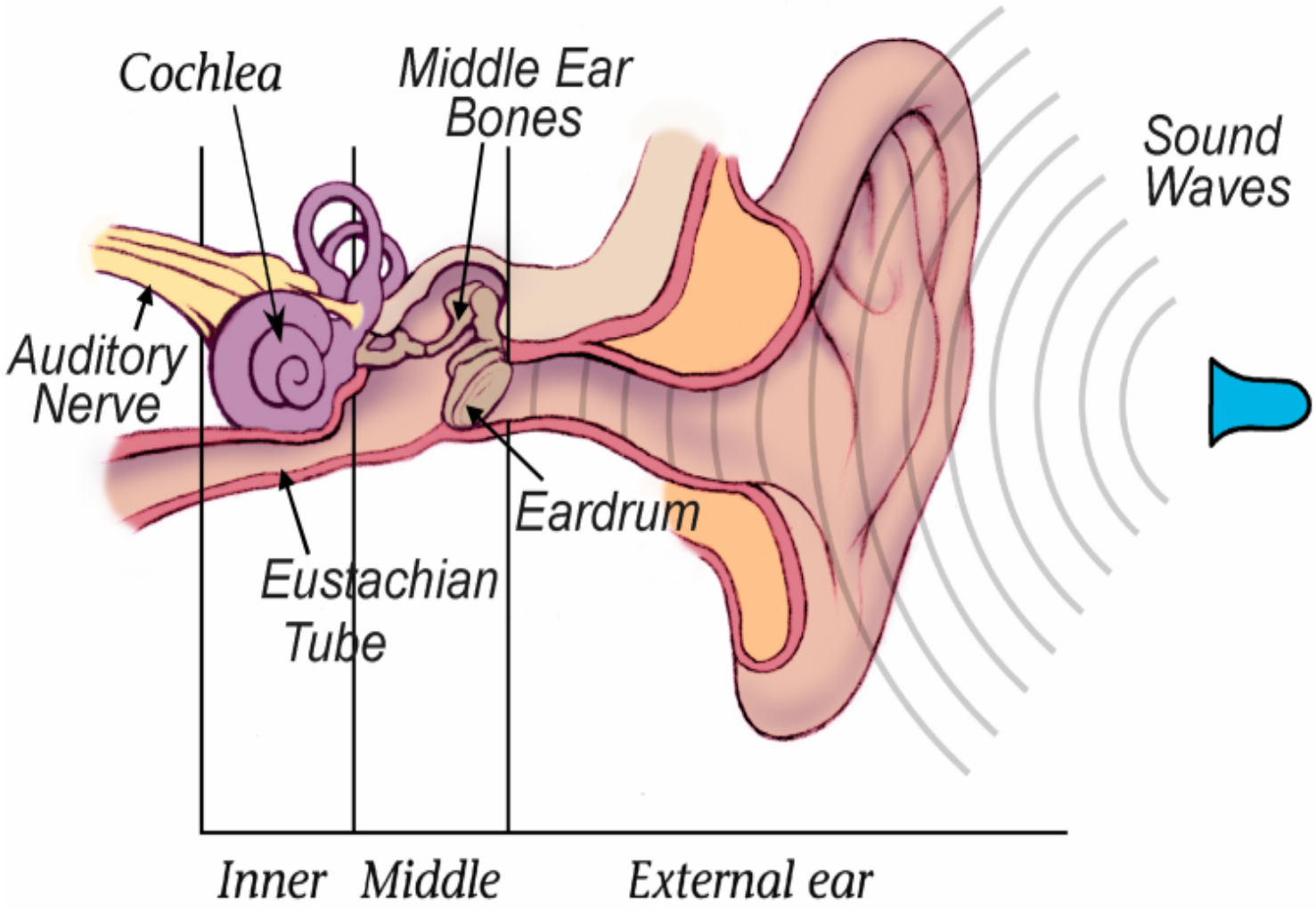
Basic anatomy of the Ear



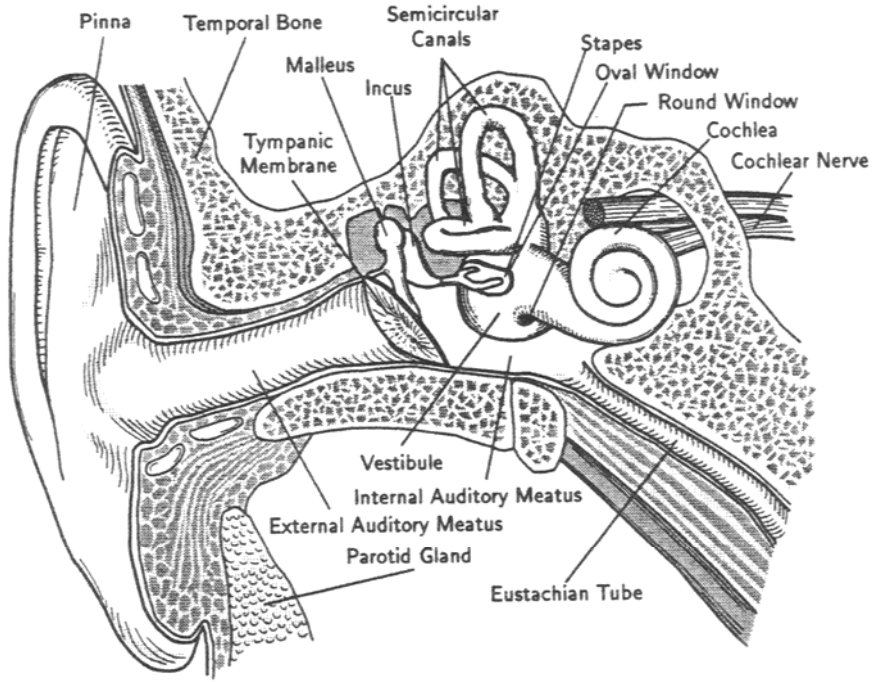


Figure 2.1 **Anatomy of the human auditory periphery. Adapted from Kessel and Kardon [50].**

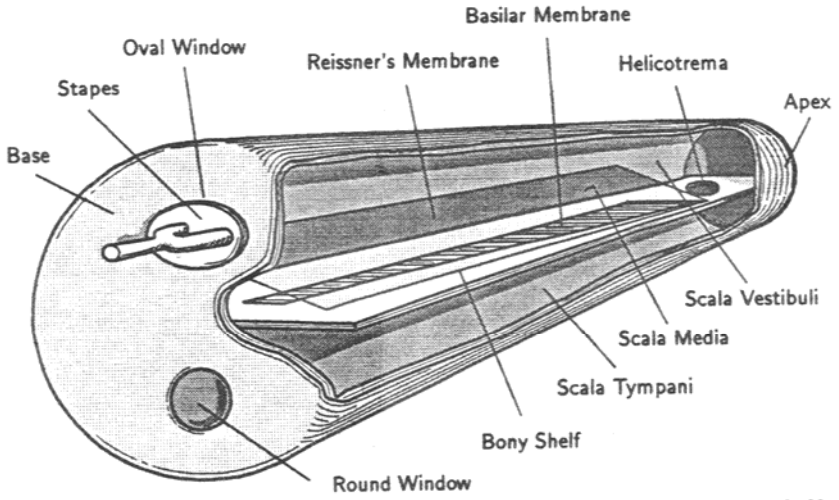


Figure 2.2 **The unrolled cochlea, simplified to emphasize the bony shelf and widening of the basilar membrane. Adapted from Cole and Chadwick [11].**

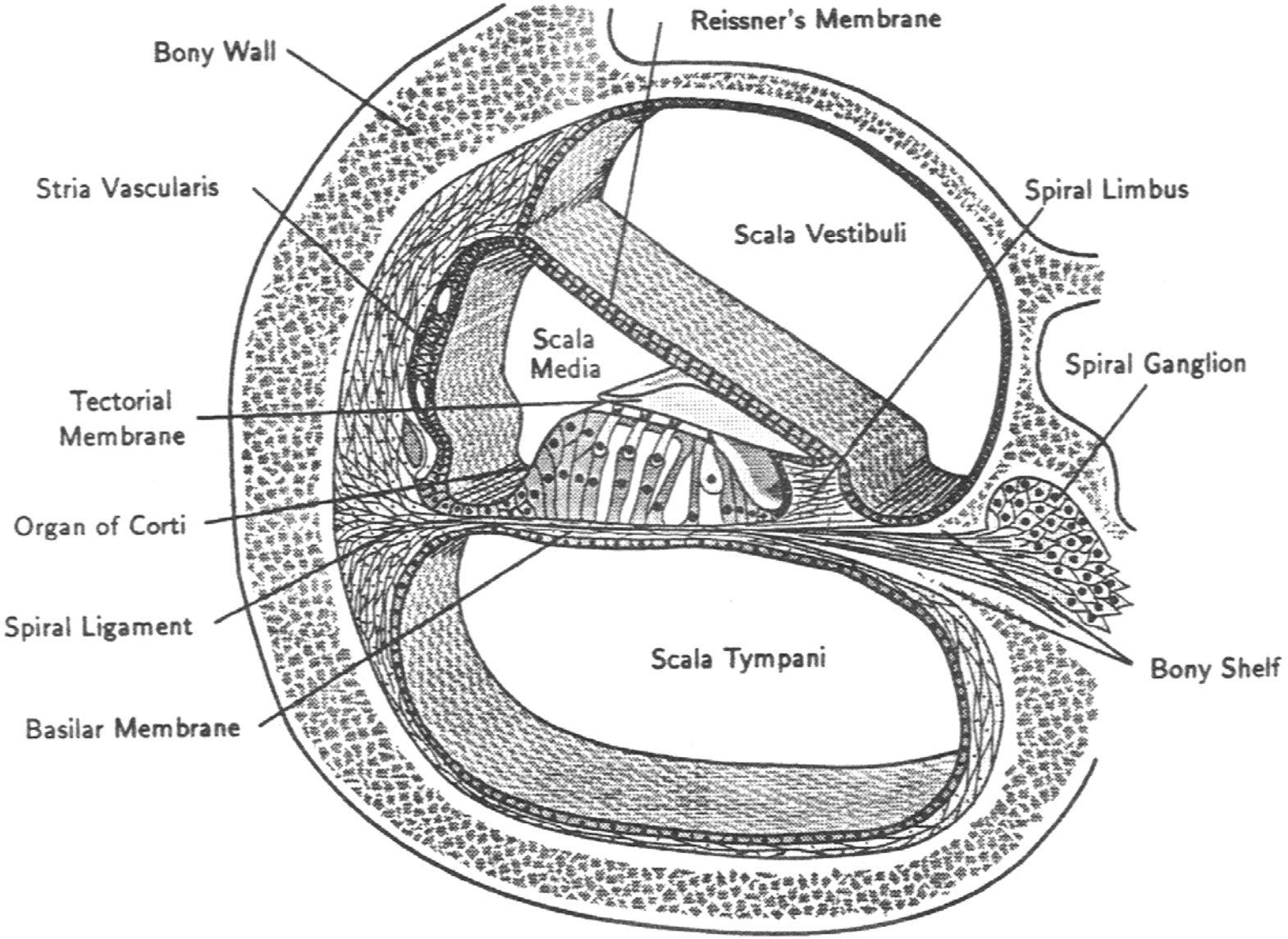
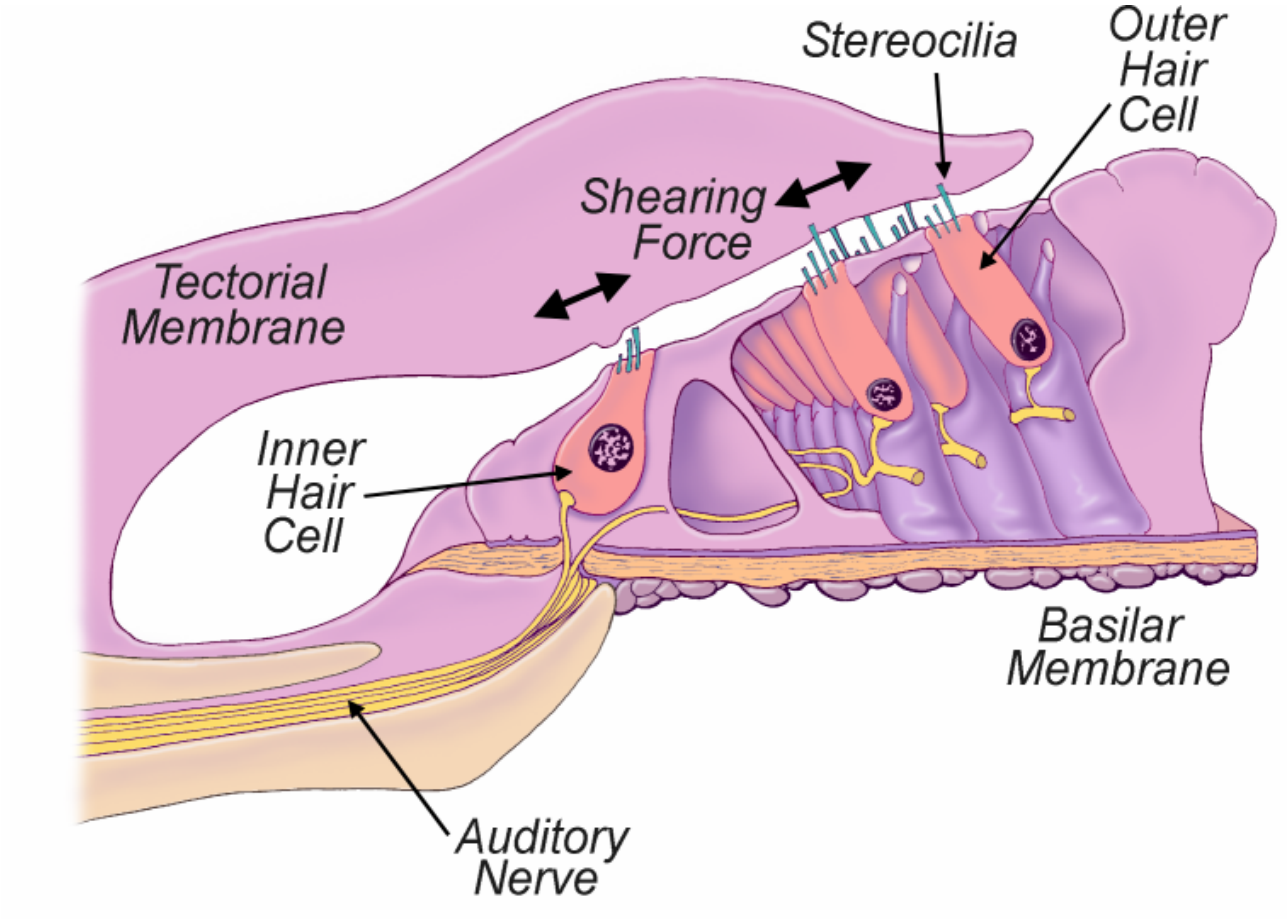


Figure 2.3 **Cross-section through the cochlea. Adapted from Kessel and Kardon [50].**

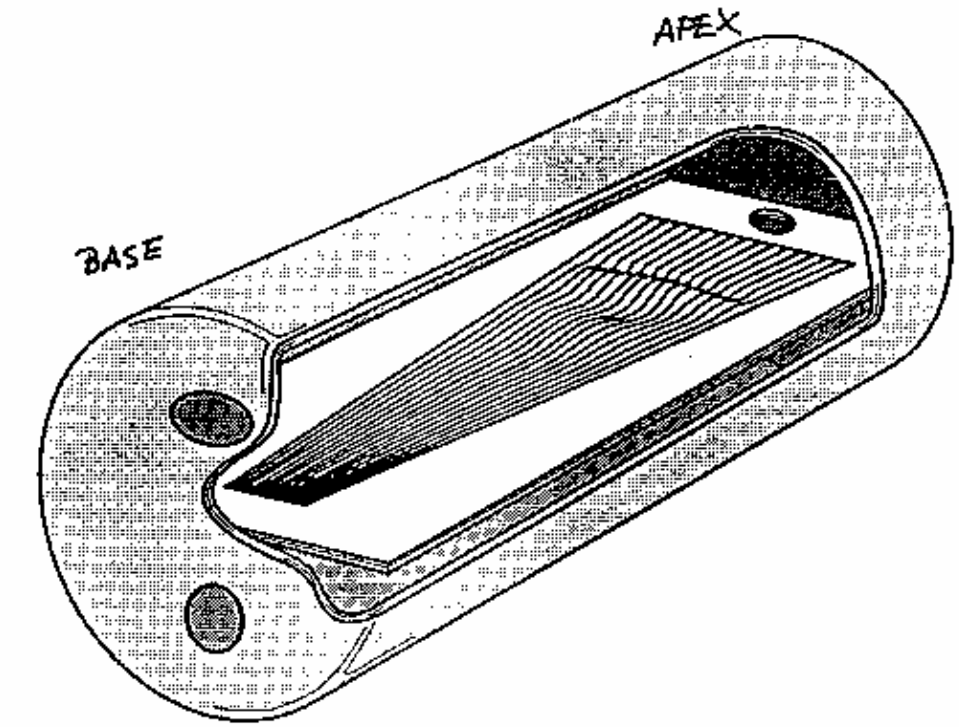
The Organ of Corti

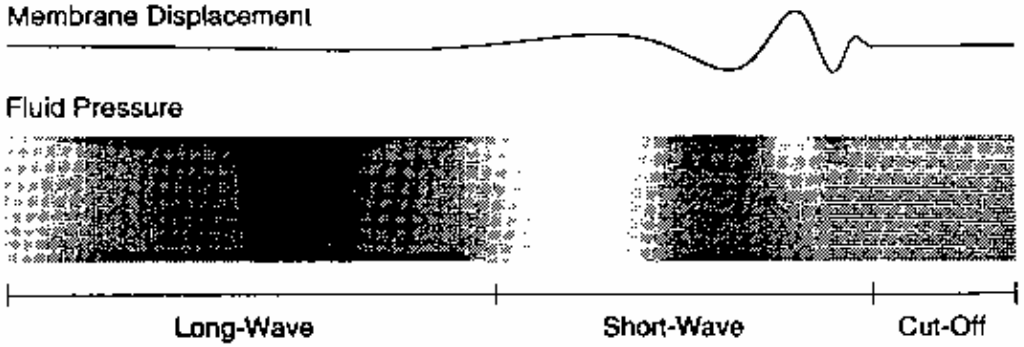


Inner Hair Cell: mechanoelectrical transducer to report signal to the brain.

Outer Hair Cell: mechano-electro-mechanical amplifier that pumps mechanical energy back into the moving basilar membrane

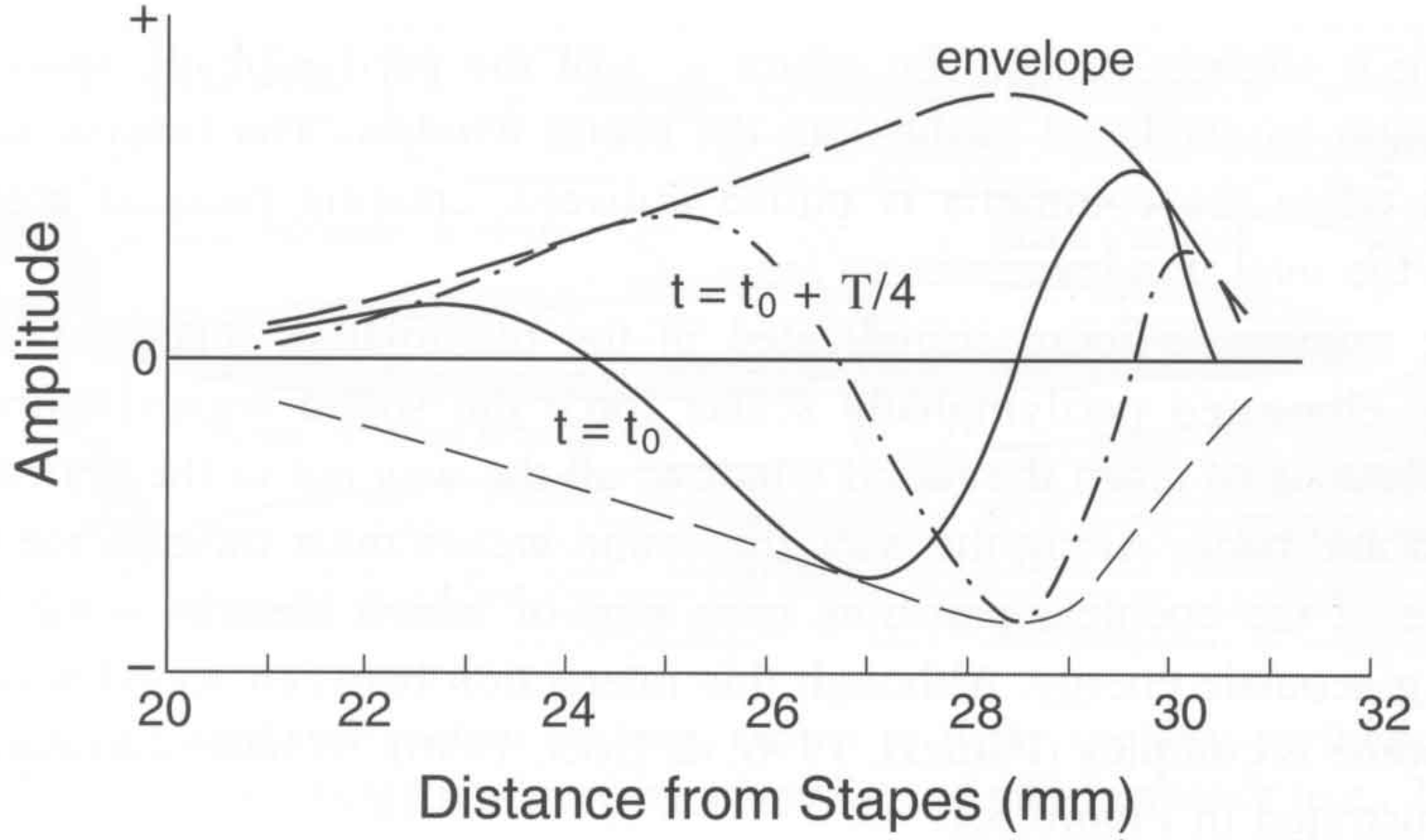
A View of the Human Cochlea





1. Fluid pressure causes the basal part of the membrane to move
2. The moving membrane squirts fluid towards the base and apex as it moves vertically
3. The moving fluid excites more membrane that is up ahead (more apical)
4. The cycle continues and we get a traveling wave

The Traveling Wave

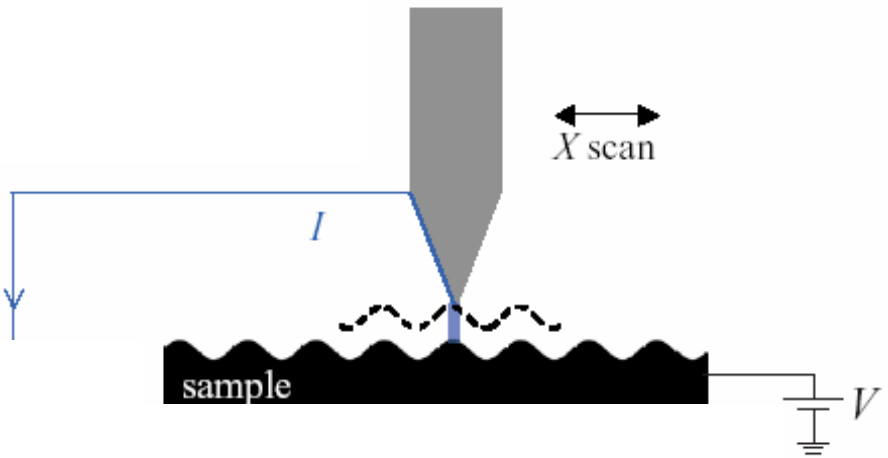


Von Békésy (1947)

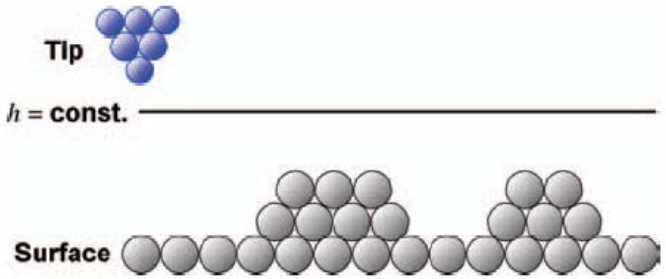
	Dynamic Range (dB)	**Power** (μW)
Ear	120	~10
Silicon Cochlea	60	~500

Scanning Tunneling Microscopy

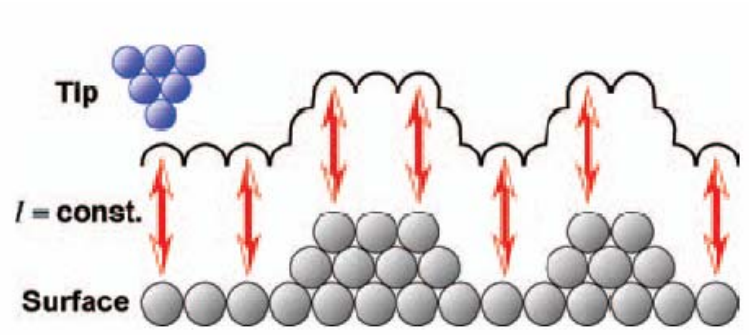
Binnig and Rohrer (IBM), 1986 Nobel Prize

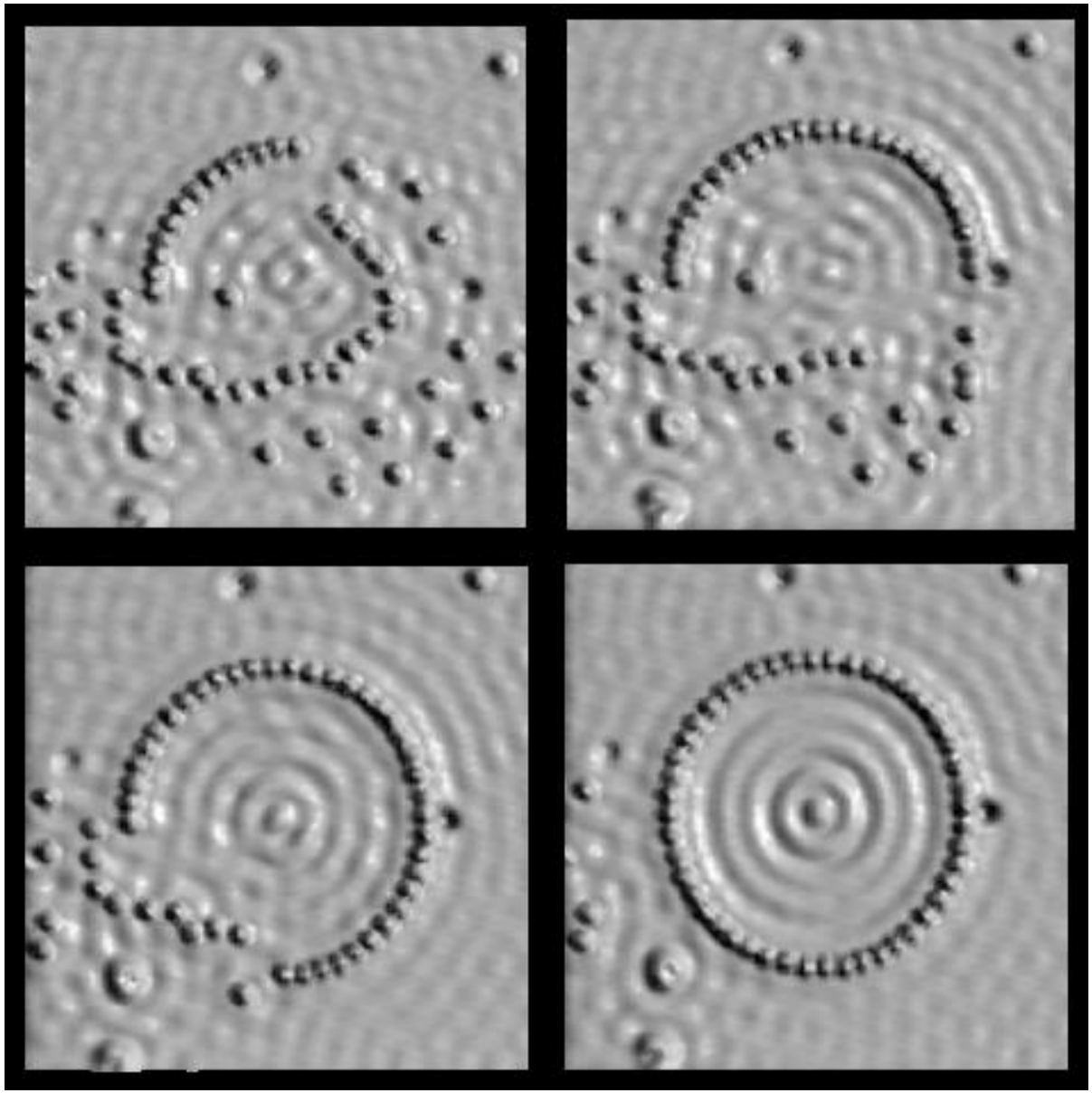


$$I \sim V \mathrm{e}^{-\alpha\sqrt{\phi}\, z}$$

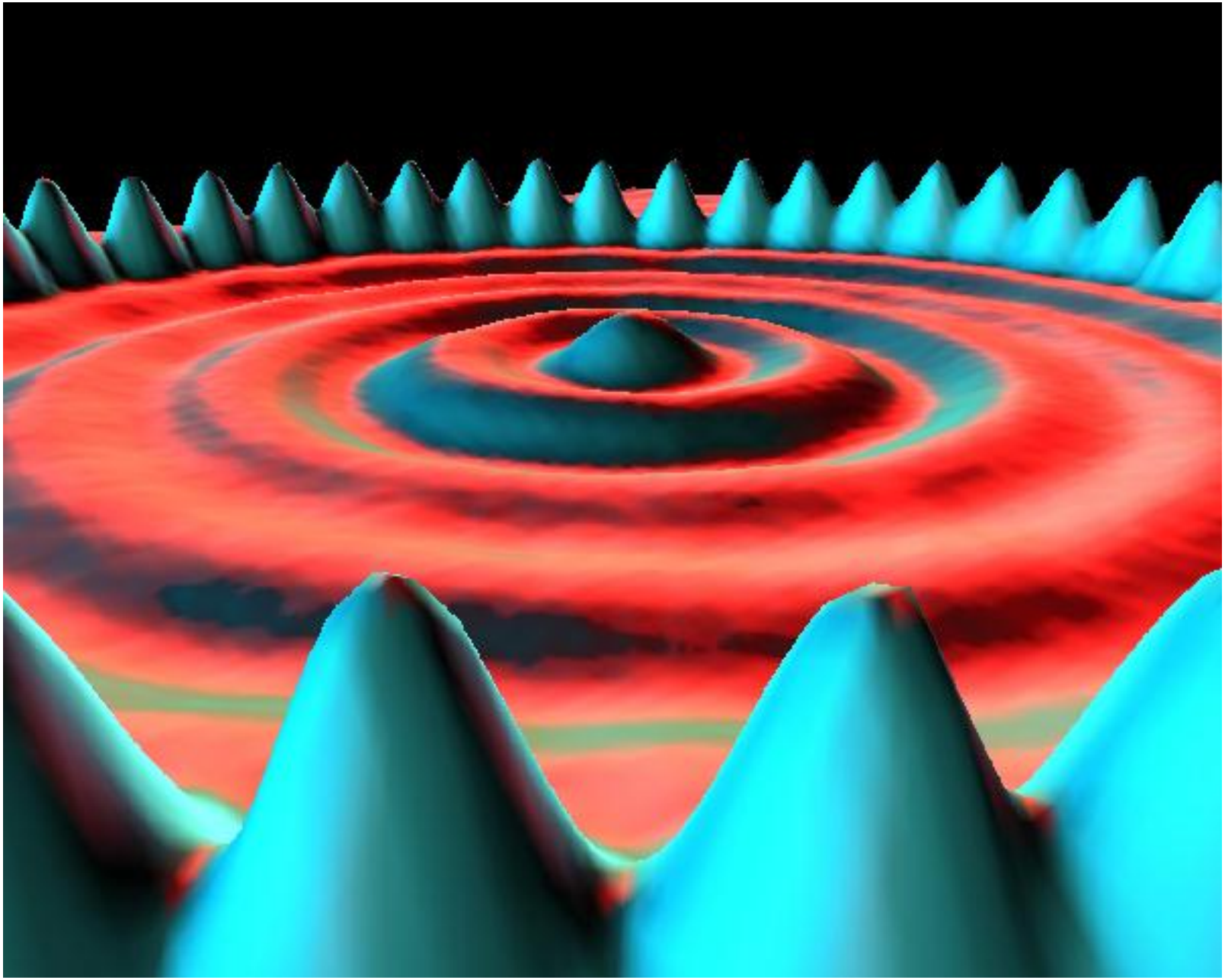


Feedback and Z-actuator are used to keep current constant:





Eigler, IBM



Eigler, IBM

Atomic Force Microscope

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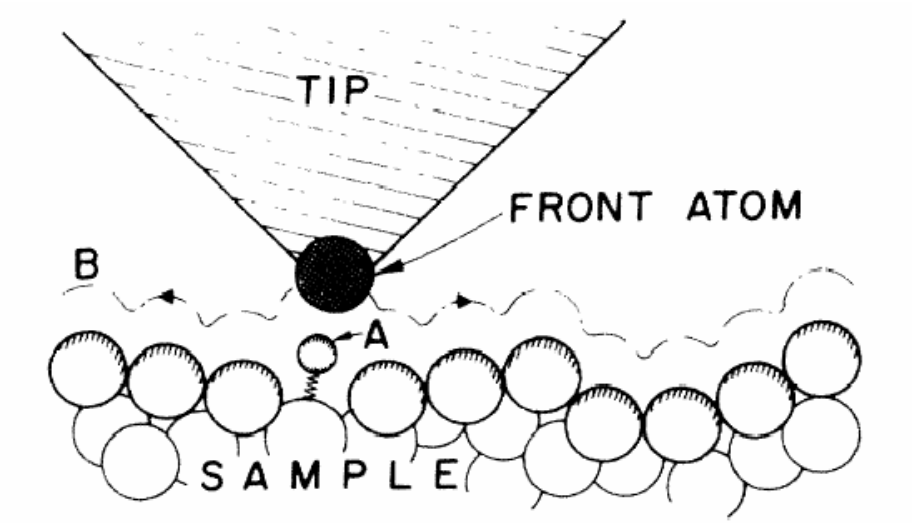
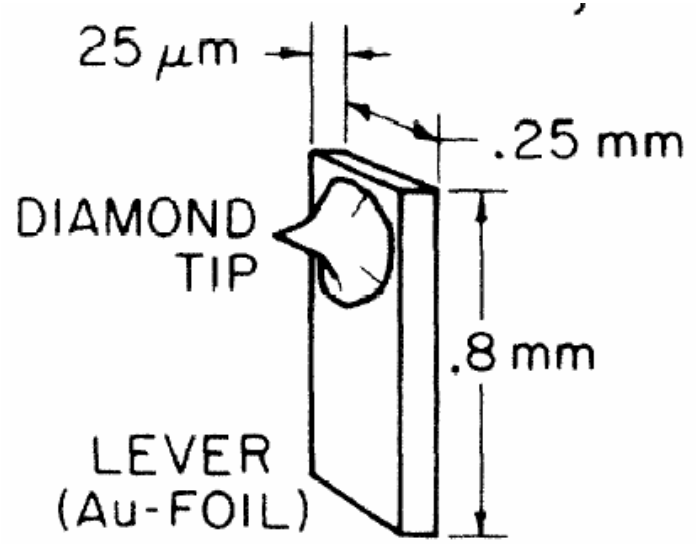
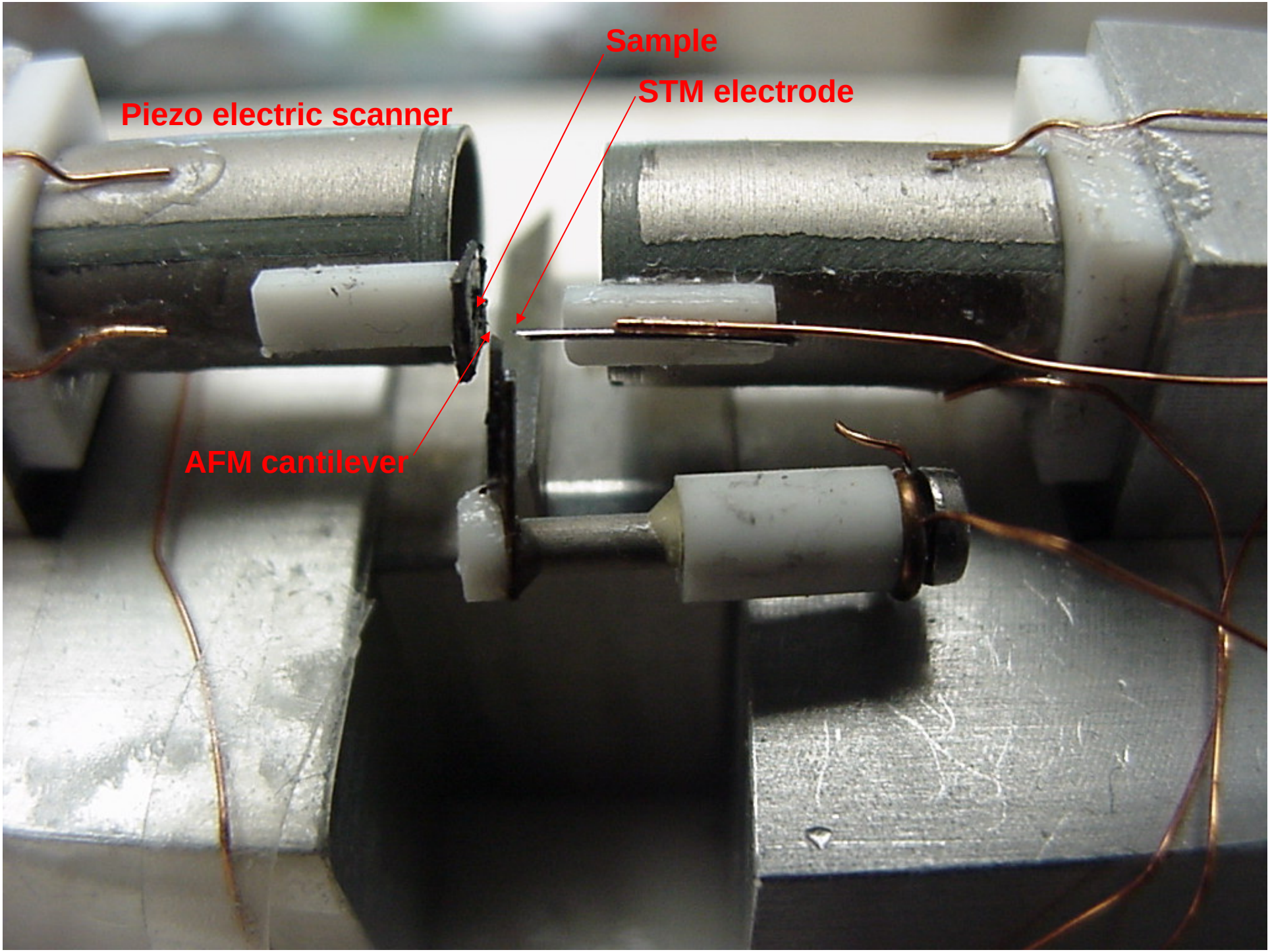
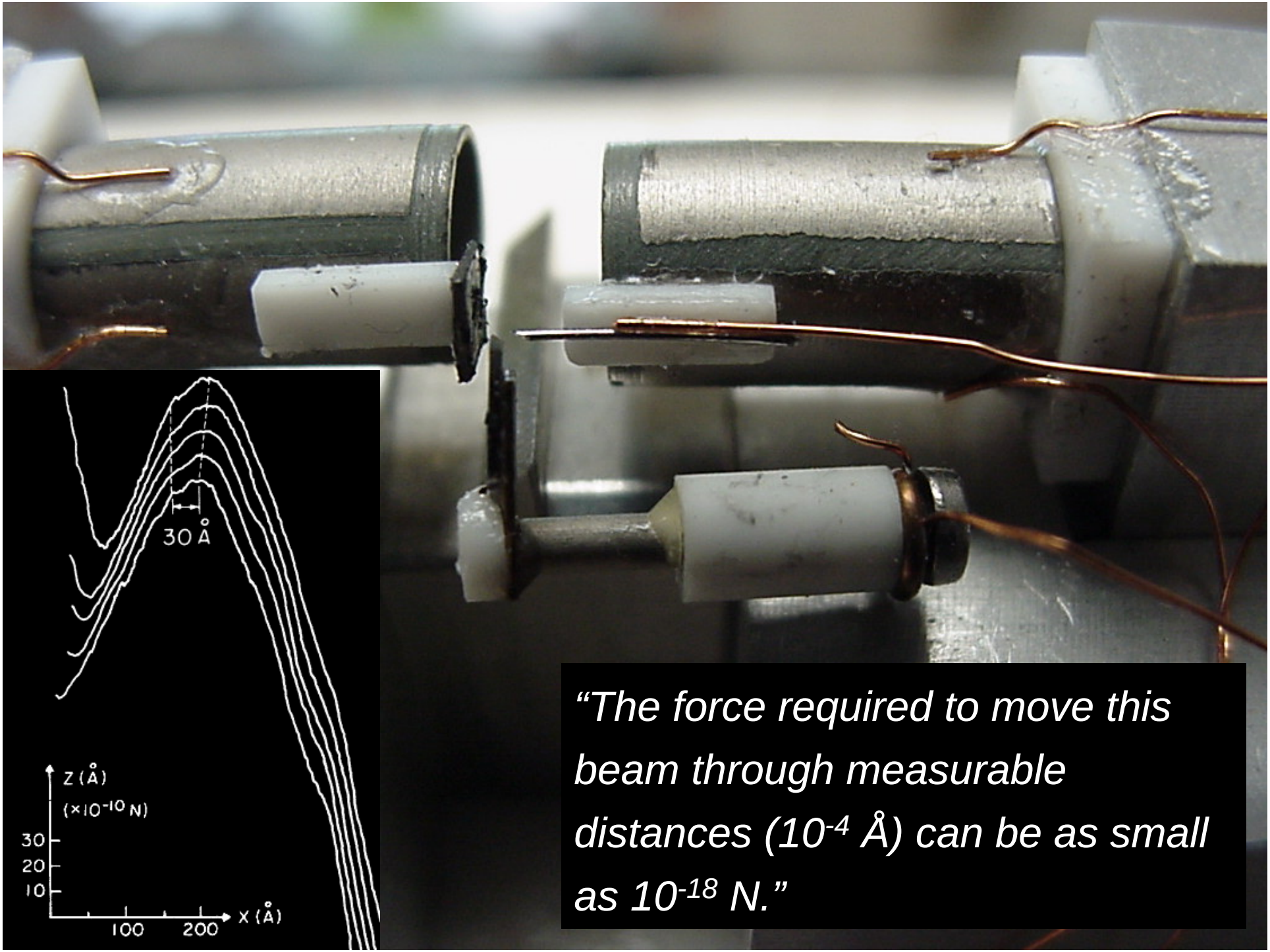
Edward L. Ginzton Laboratory, Stanford University, Stanford, California 94305
and
Ch. Gerber[c]
IBM San Jose Research Laboratory, San Jose, California 95193
(Received 5 December 1985)



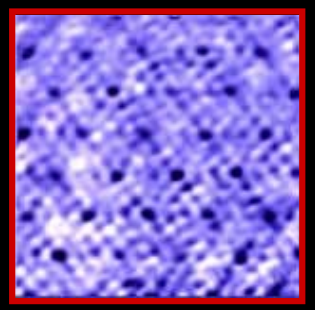



Sample
STM electrode
Piezo electric scanner
AFM cantilever

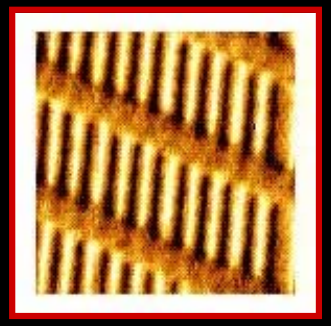


"The force required to move this beam through measurable distances (10^{-4} Å) can be as small as 10^{-18} N."

AFM laboratory applications

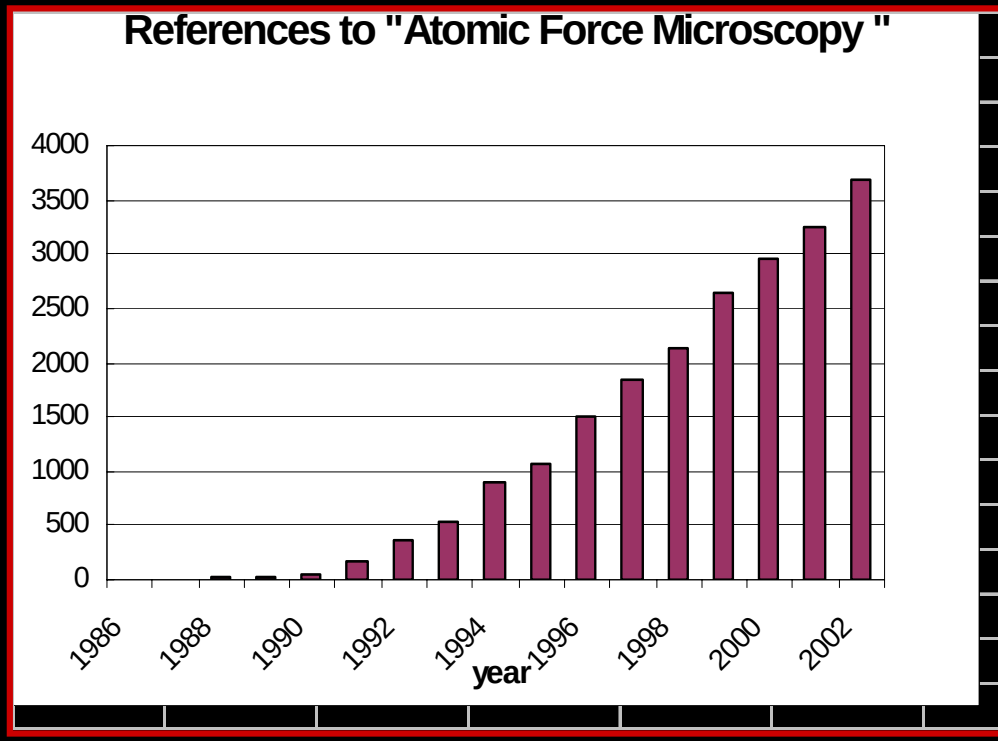


- Fundamental physics
- Magnetic forces

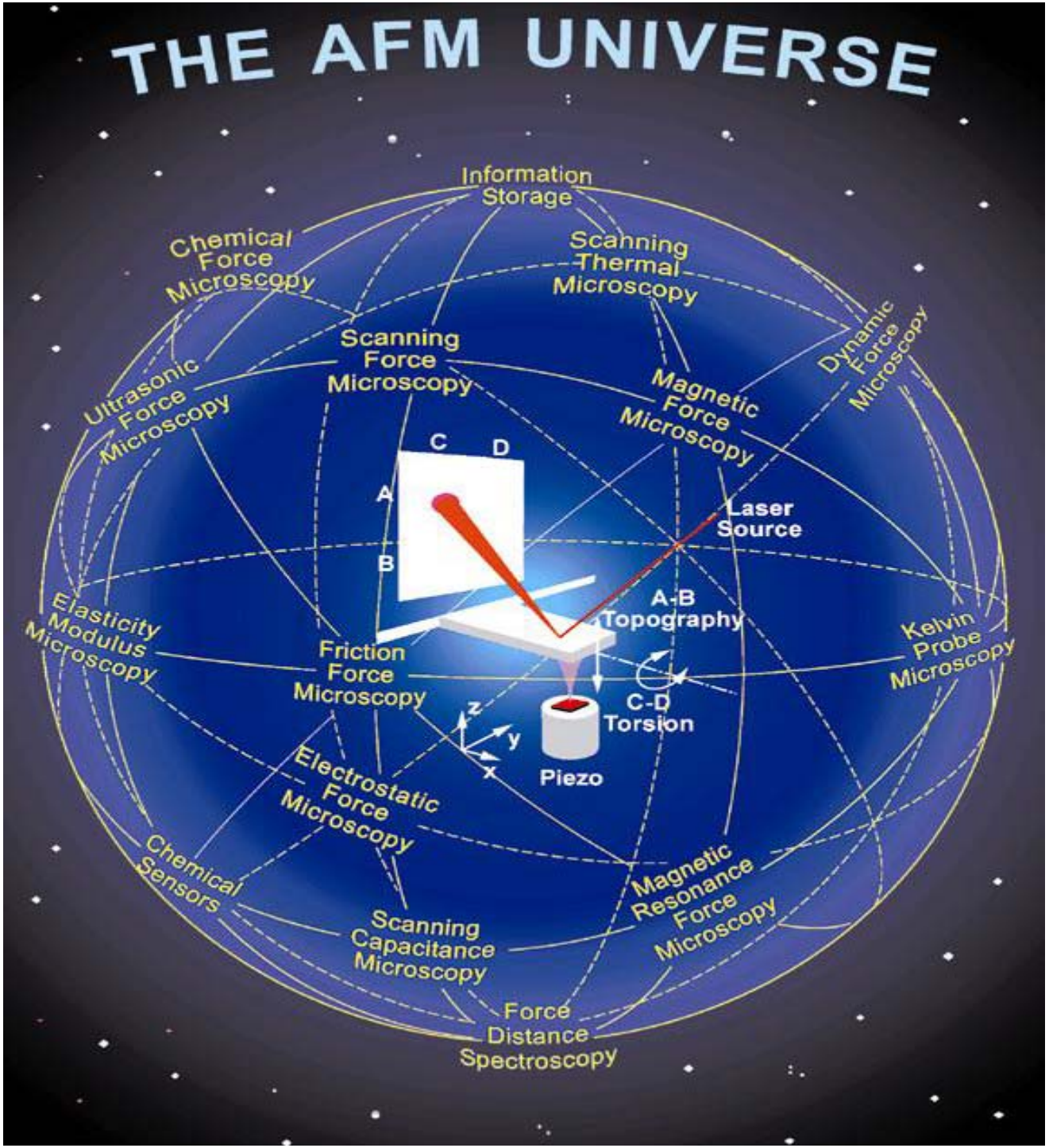


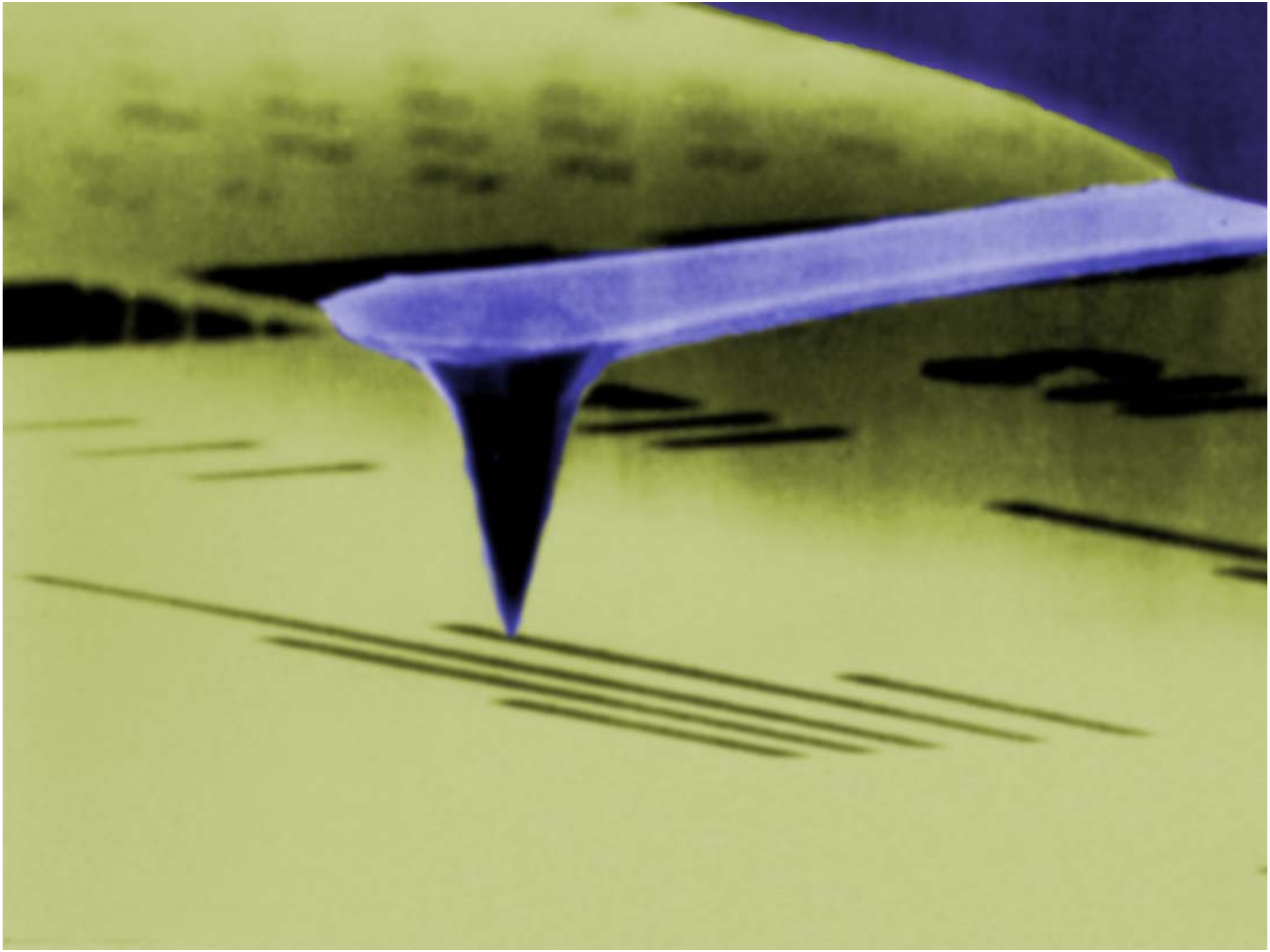
- Tribology
- Biology

- Chemistry

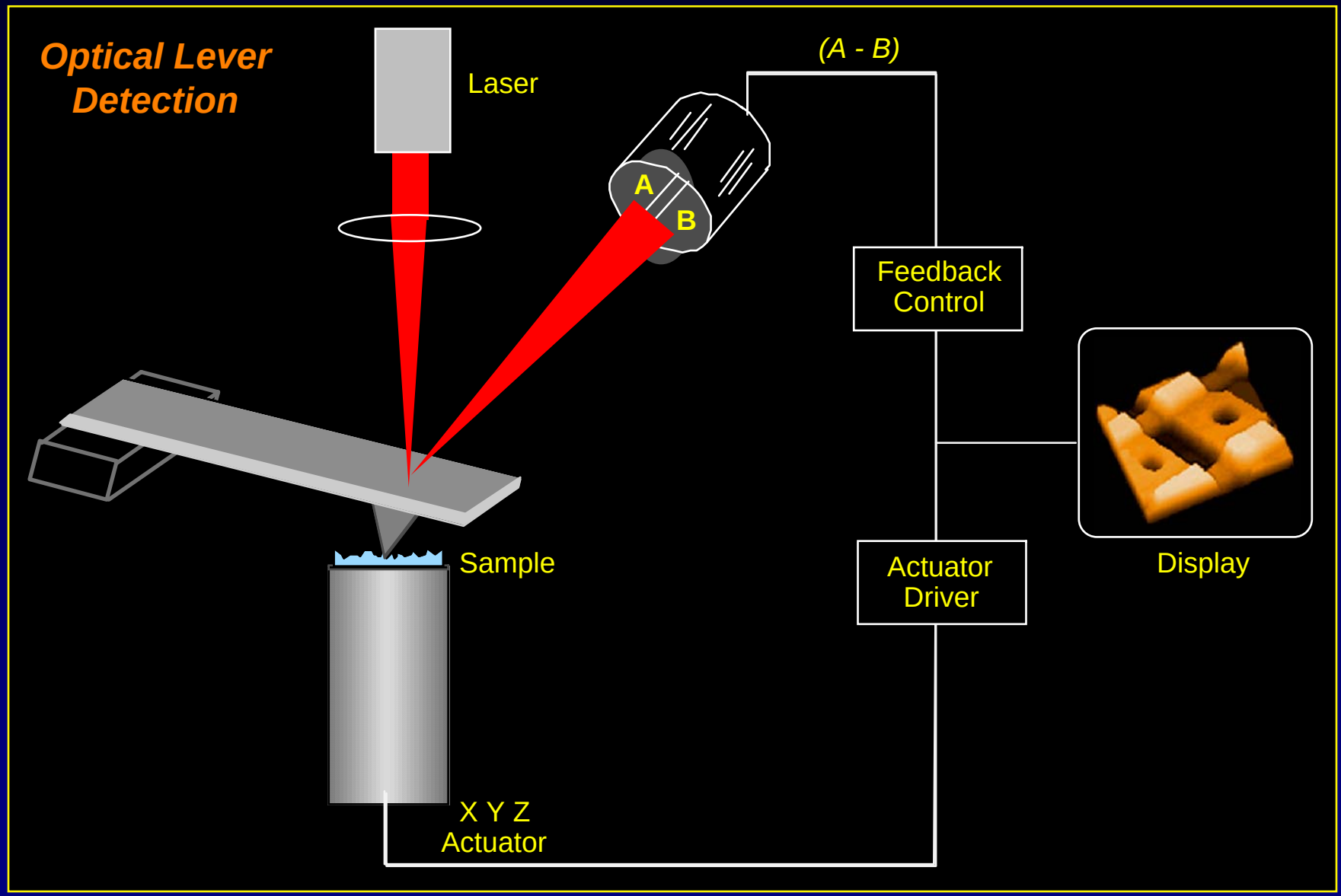


images from thermomicroscope

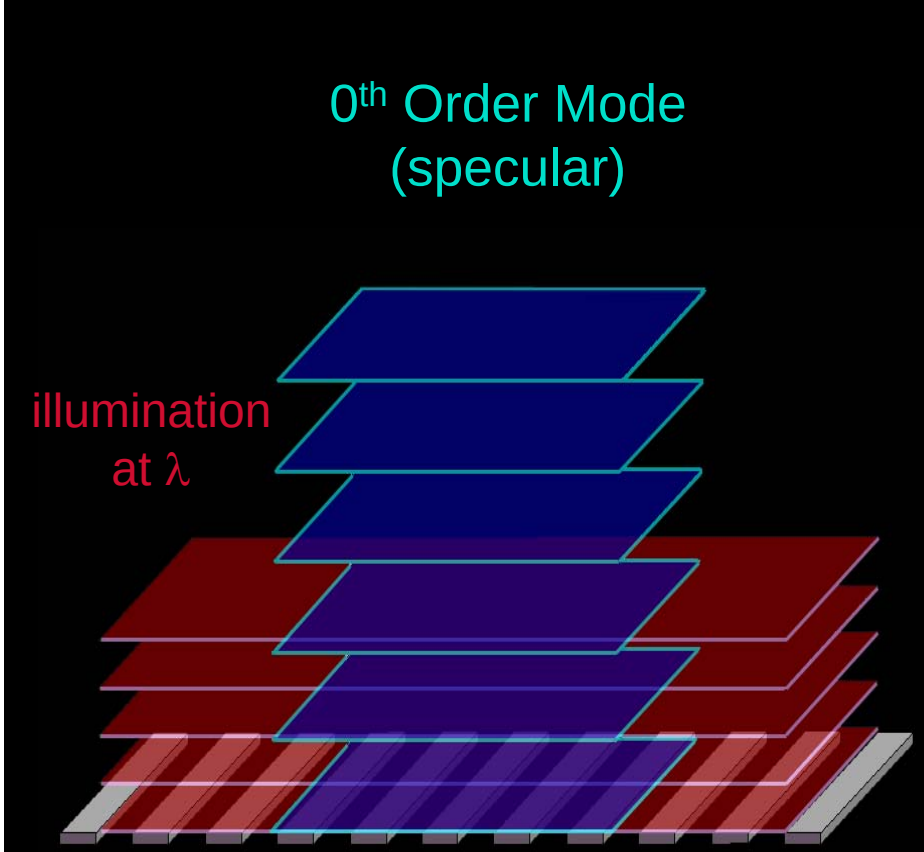

THE AFM UNIVERSE
Information Storage
Chemical Force Microscopy
Scanning Thermal Microscopy
Scanning Force Microscopy
Ultrasonic Force Microscopy
Magnetic Force Microscopy
Dynamic Force Microscopy
C
D
A
B
Laser Source
A-B Topography
Elasticity Modulus Microscopy
Friction Force Microscopy
Kelvin Probe Microscopy
C-D Torsion
z
y
x
Piezo
Electrostatic Force Microscopy
Chemical Sensors
Magnetic Resonance Force Microscopy
Scanning Capacitance Microscopy
Force Distance Spectroscopy

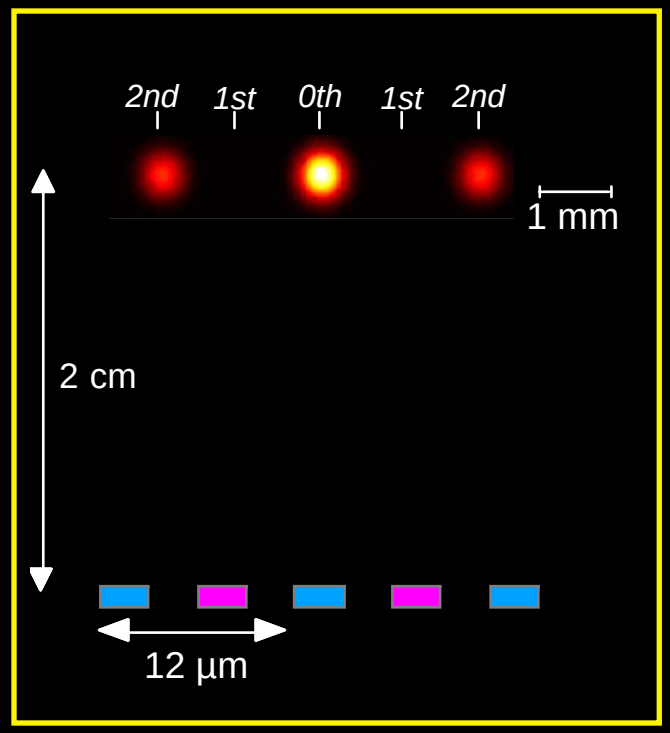


Atomic Force Microscope



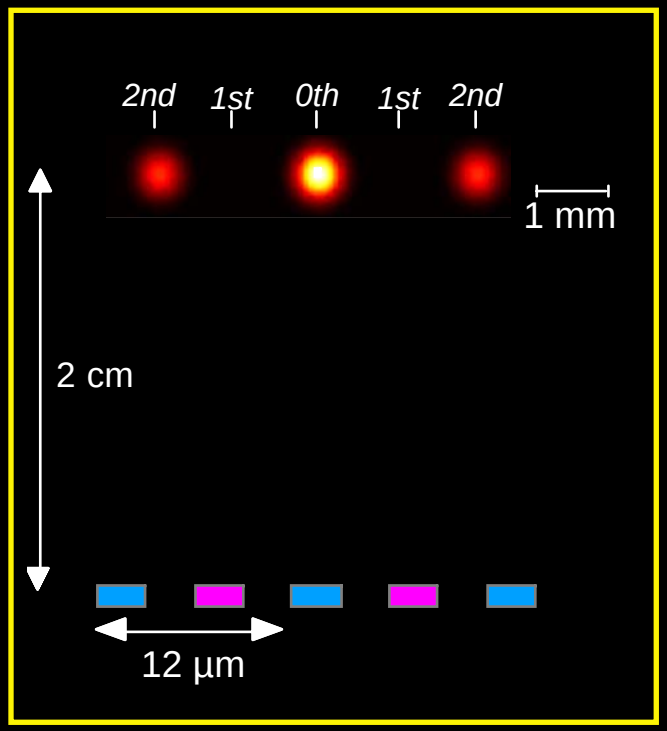
Optical Diffraction from a One Dimensional Grating



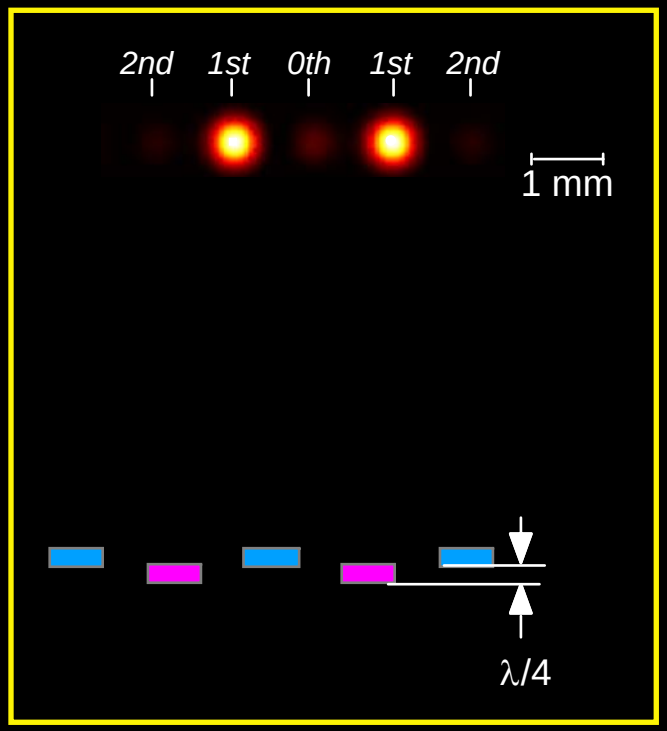


What happens when every other finger is displaced?

Fingers in same plane



Every other finger is displaced

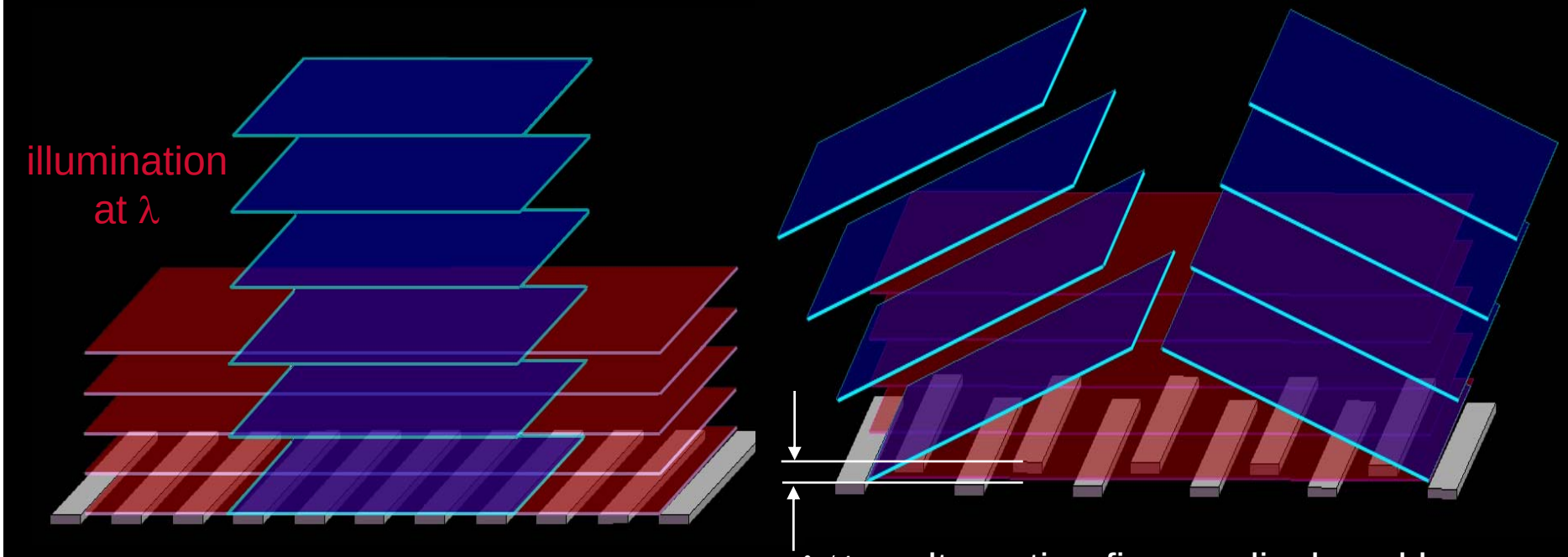


What happens when every other finger is displaced?

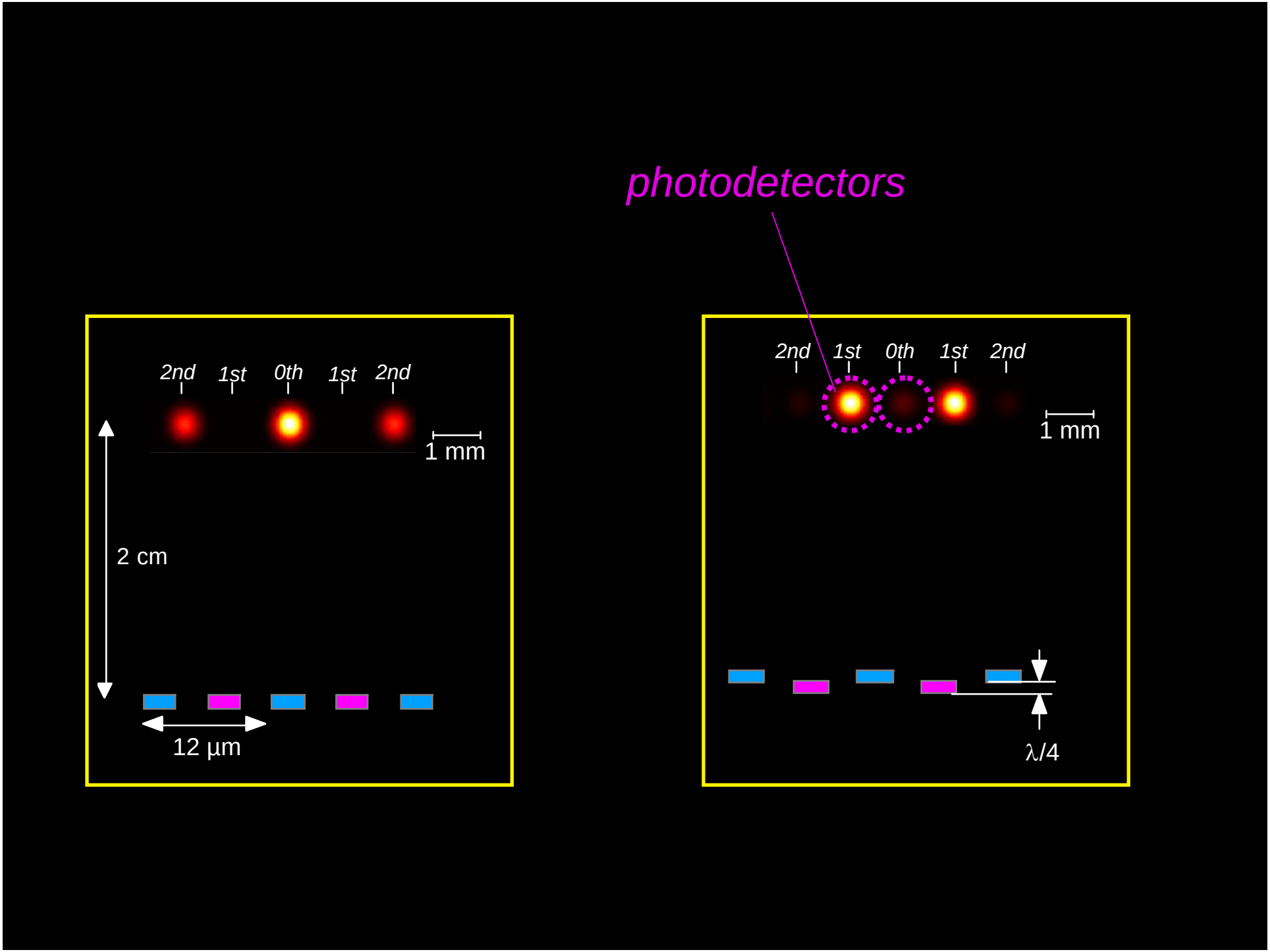
0th Order Mode (specular)

-1st Order Mode

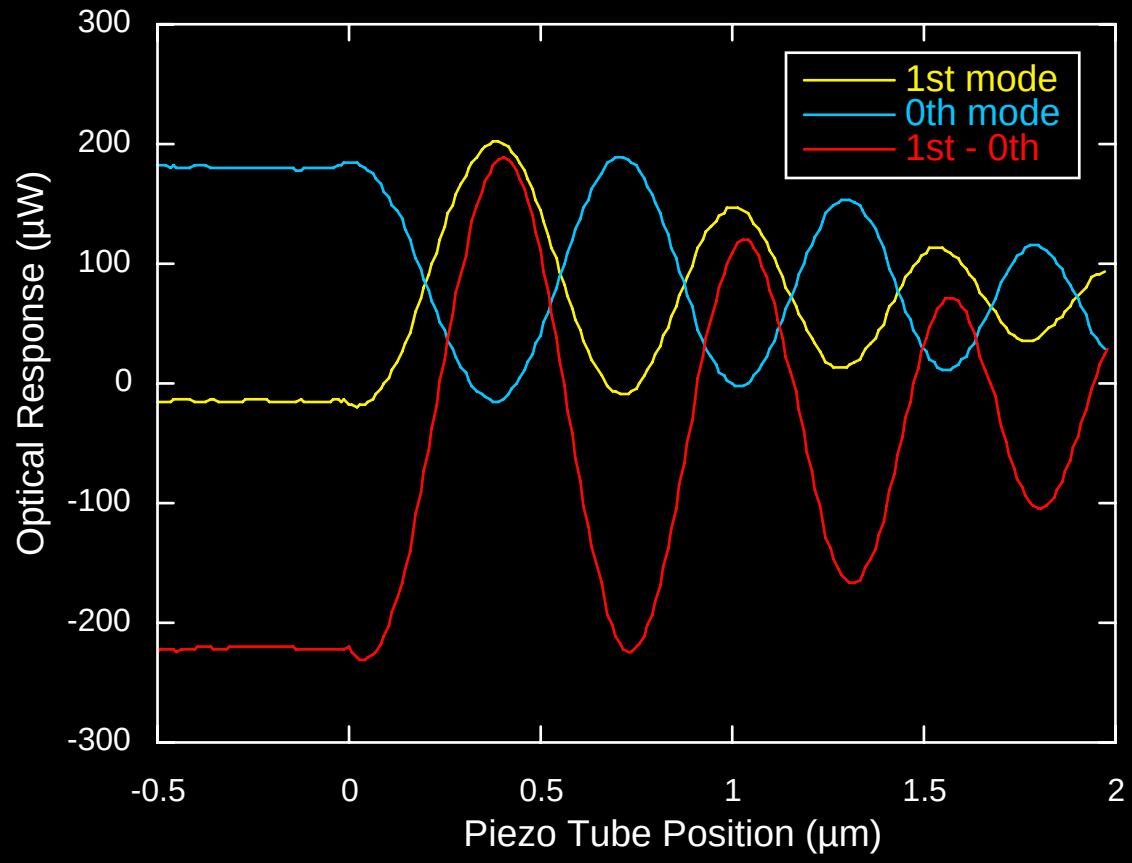
+1st Order Mode



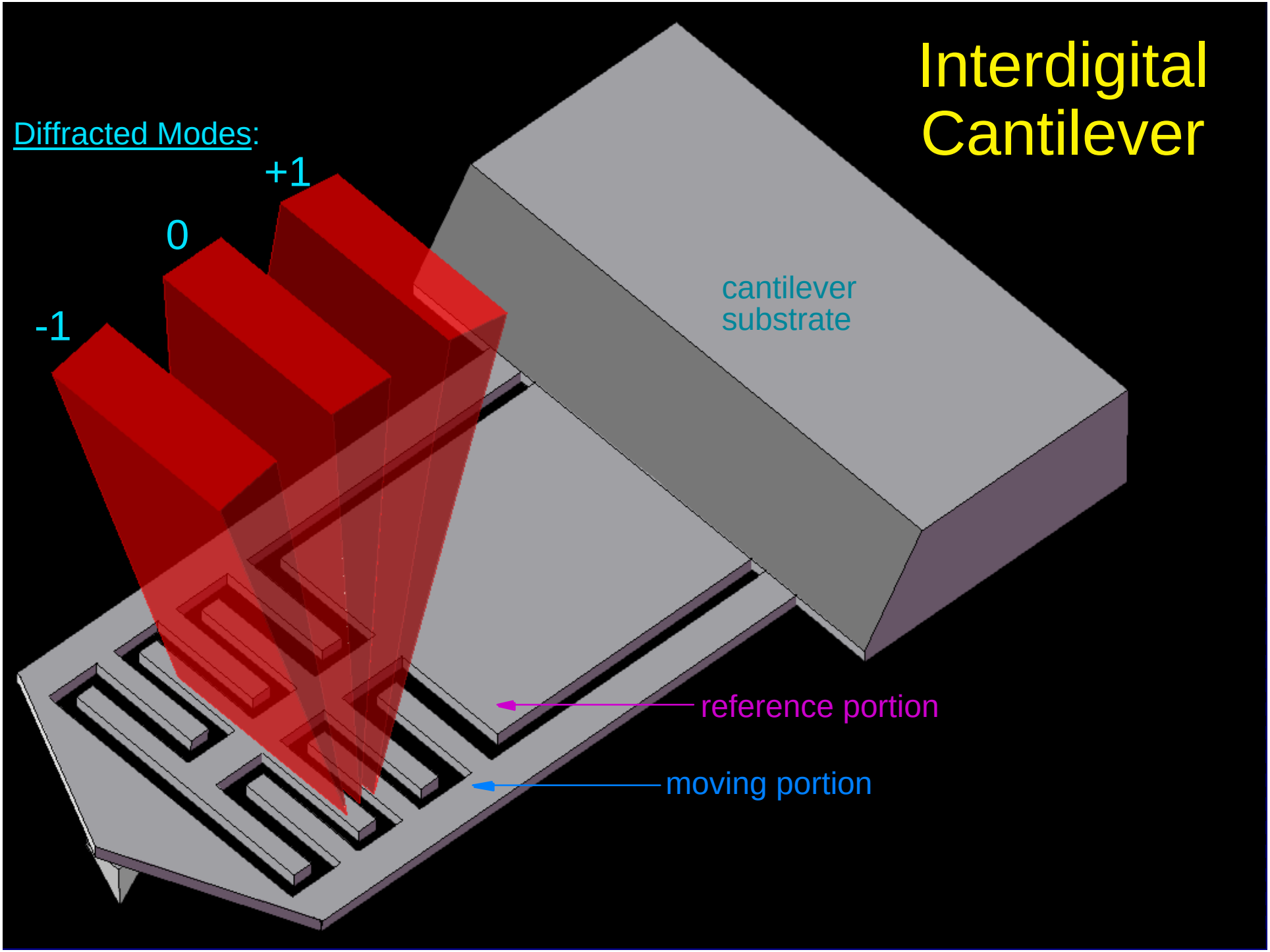
alternating fingers displaced by 1/4 of illumination wavelength


photodetectors
2nd
1st
0th
1st
2nd
1 mm
2 cm
12 µm
2nd
1st
0th
1st
2nd
1 mm
λ/4

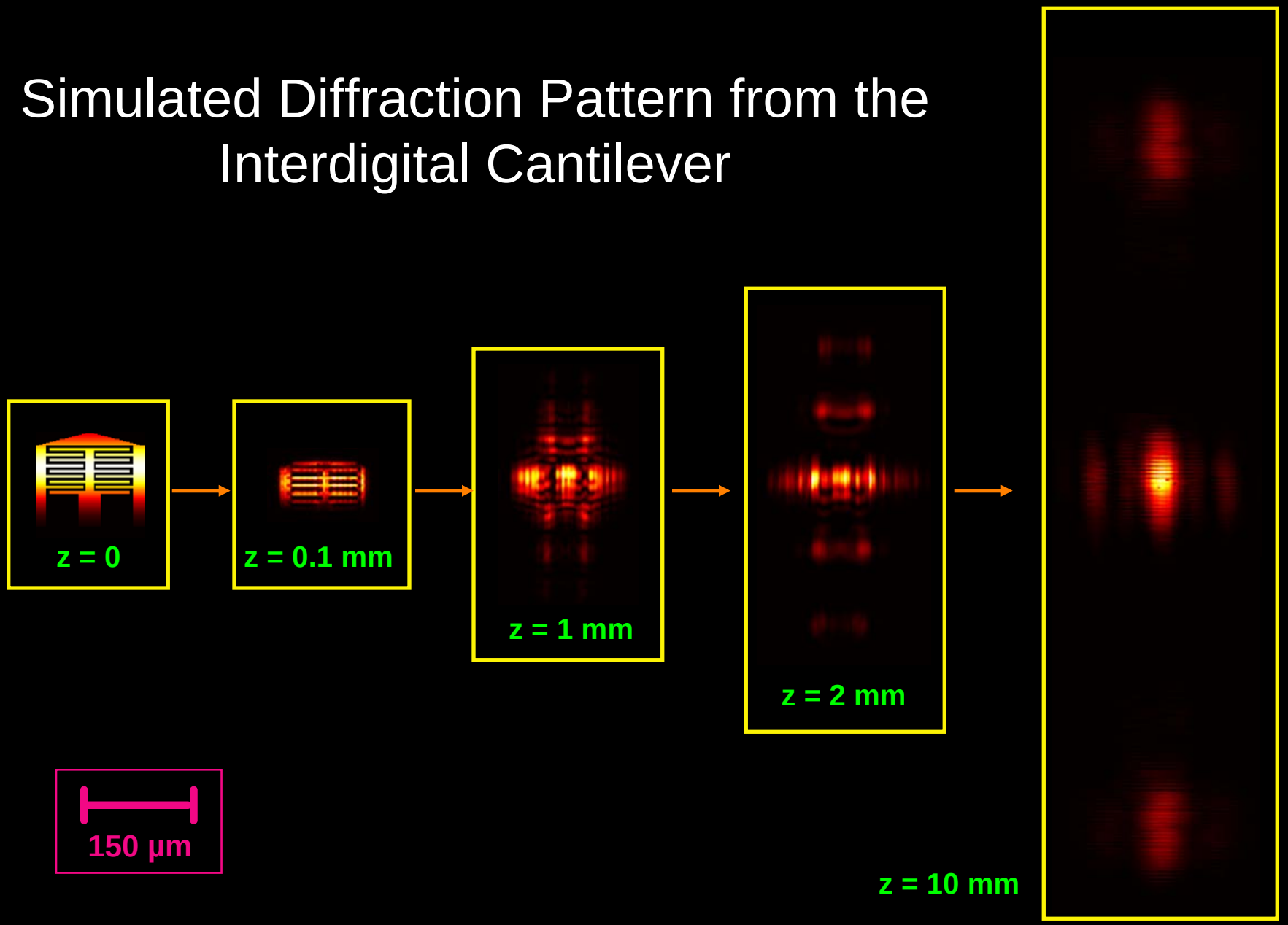
Intensity of 0th and 1st order modes



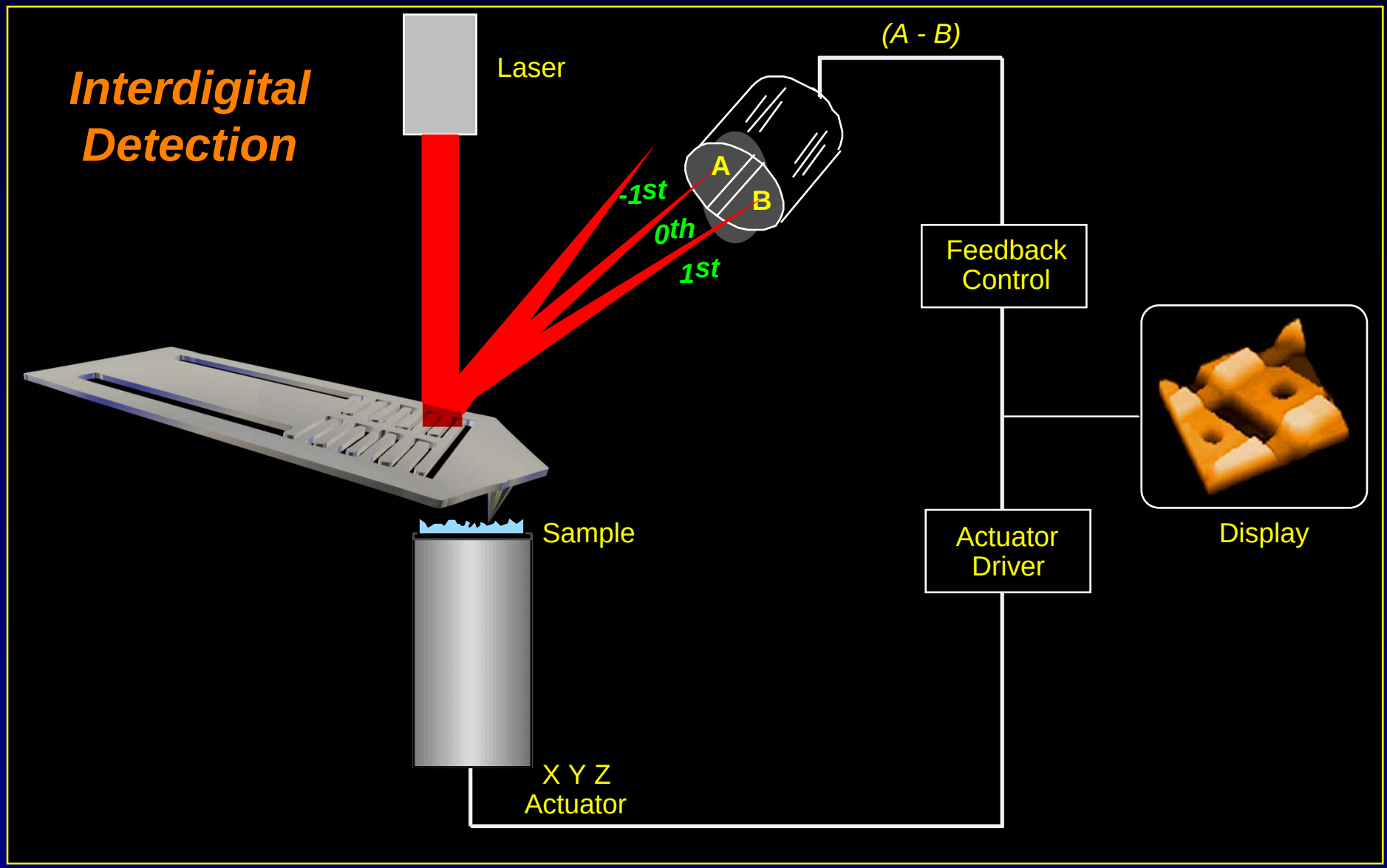
How is this implemented on an AFM cantilever?


Interdigital Cantilever
Diffracted Modes:
+1
0
-1
cantilever substrate
reference portion
moving portion

Simulated Diffraction Pattern from the Interdigital Cantilever



Atomic Force Microscope



Atomic Force Microscope