ME597/PHYS57000
Fall Semester 2009
Lecture 27

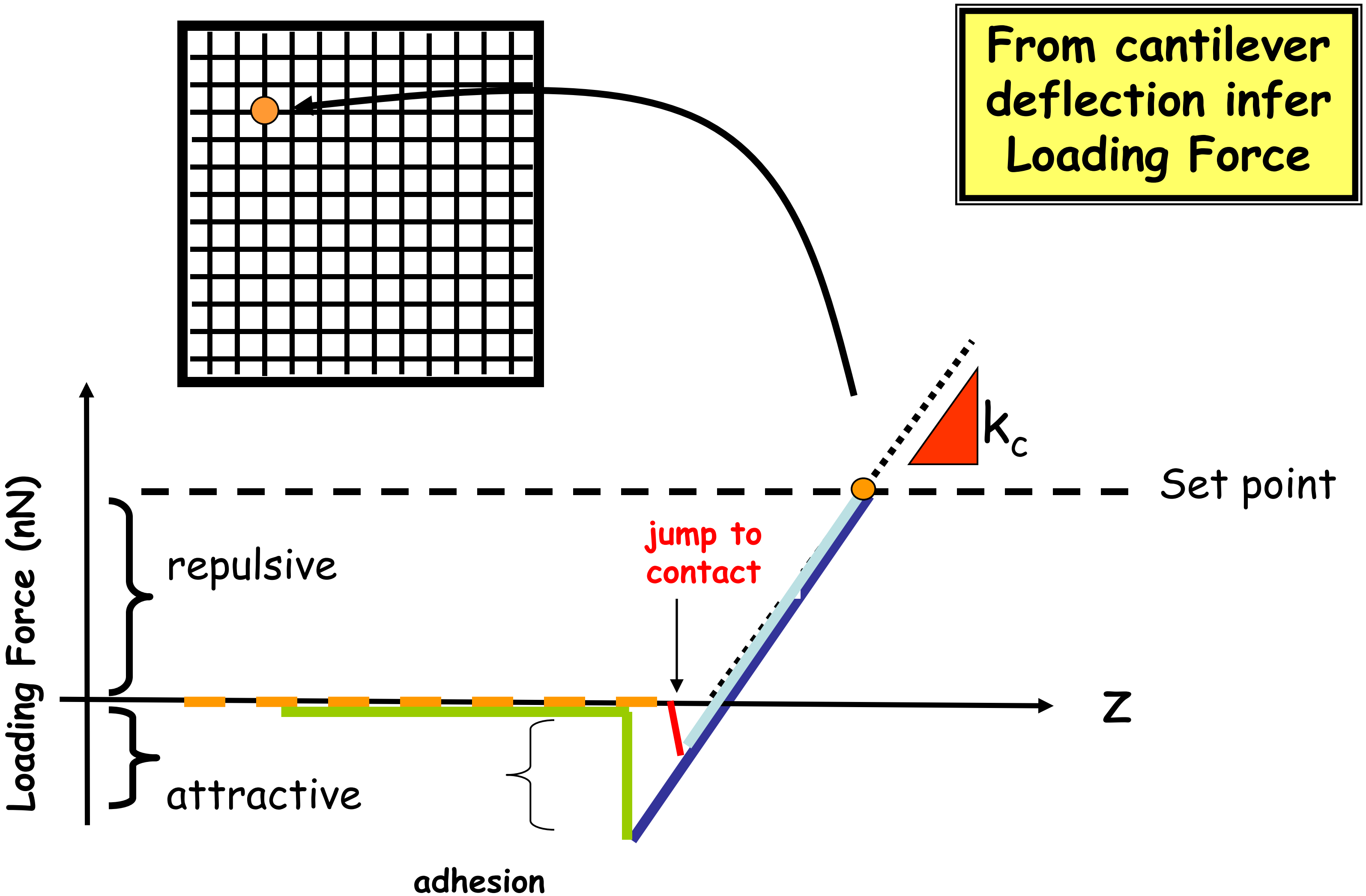
Recent Advances in AFM

- Unifying Theme -

taking advantage of cantilever modes

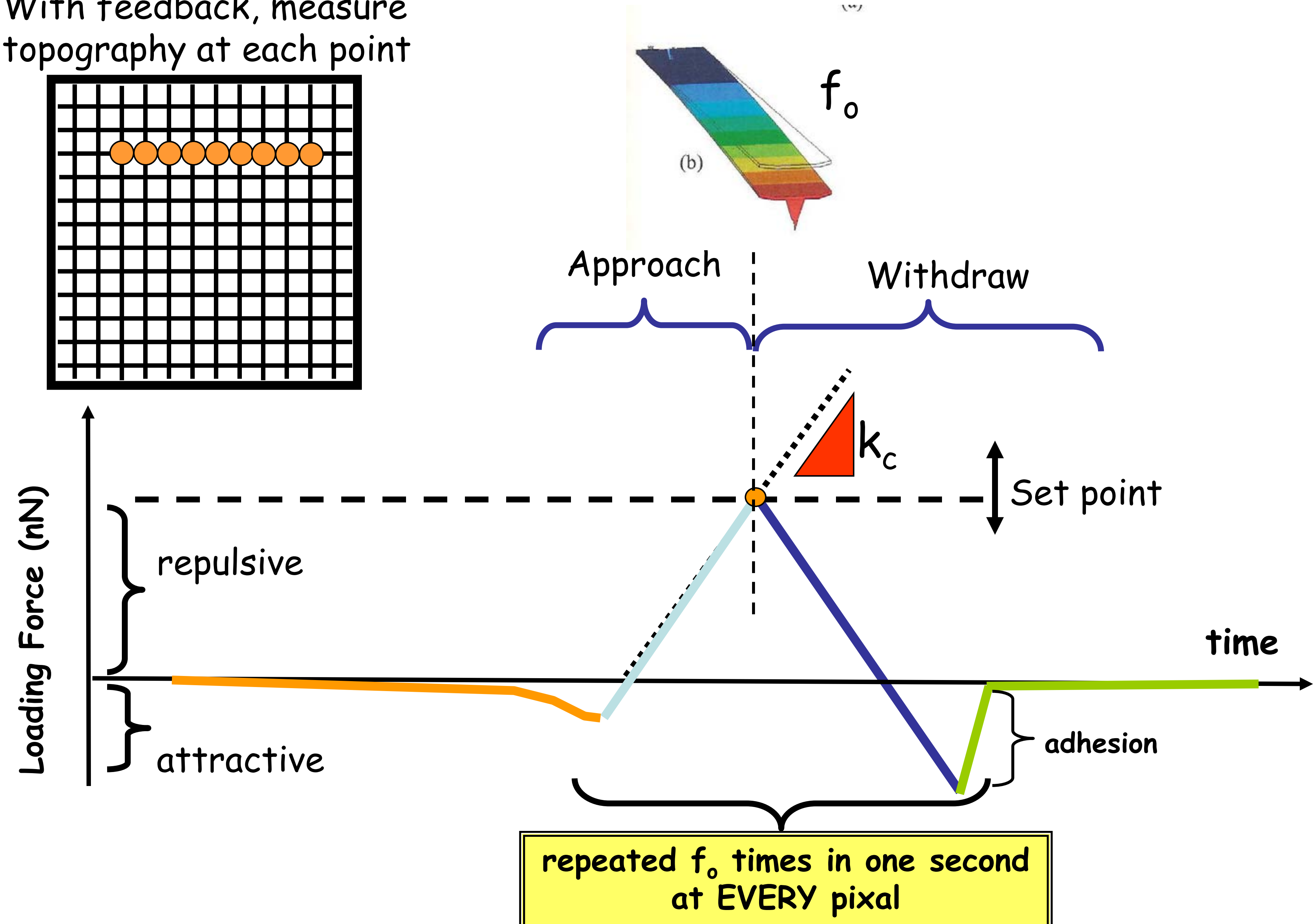
Force vs. Distance provides material properties

Force vs. Distance at **one** point

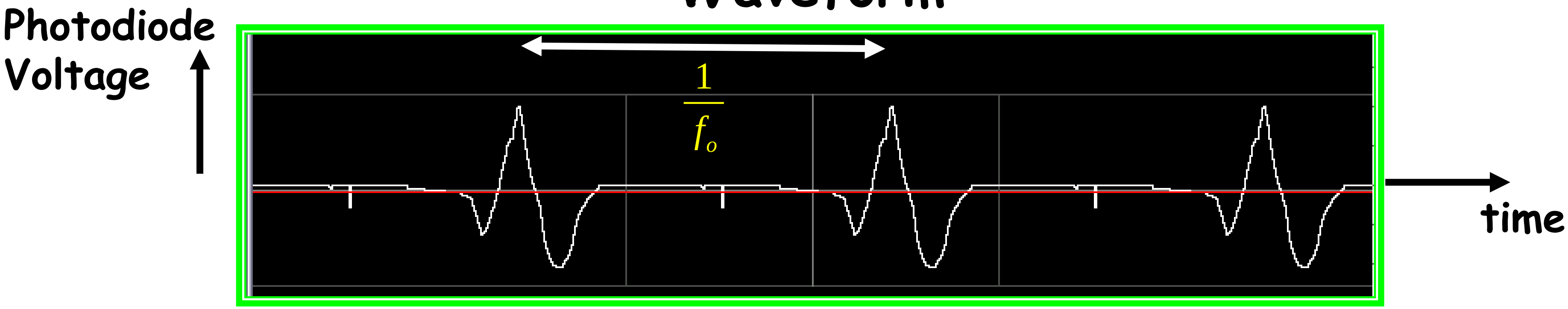


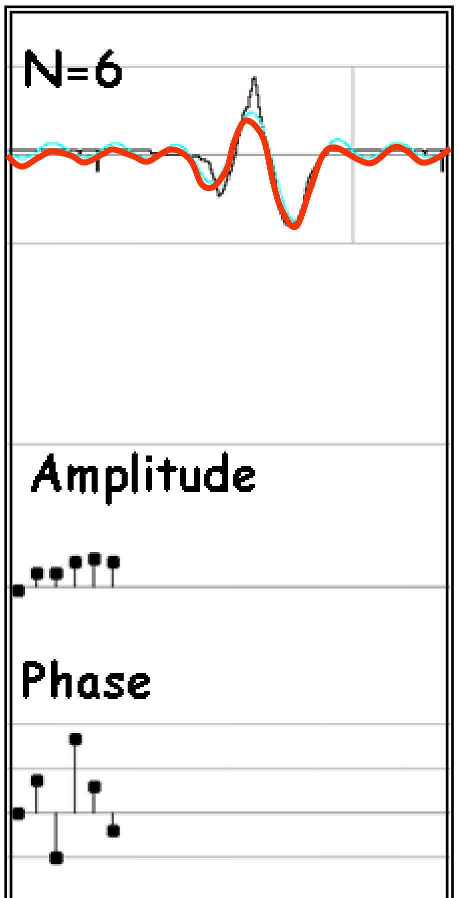
Force vs. Time in dAFM

With feedback, measure topography at each point



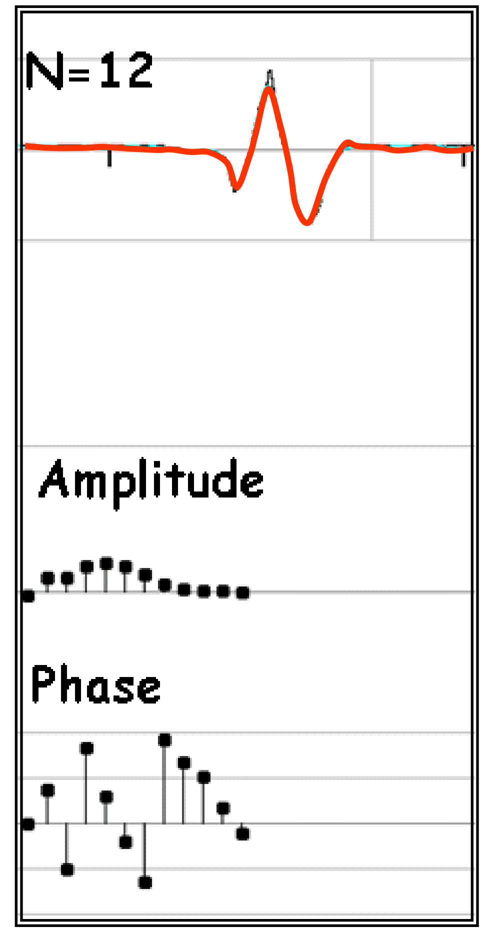
Waveform





Fourier Transform of Waveform

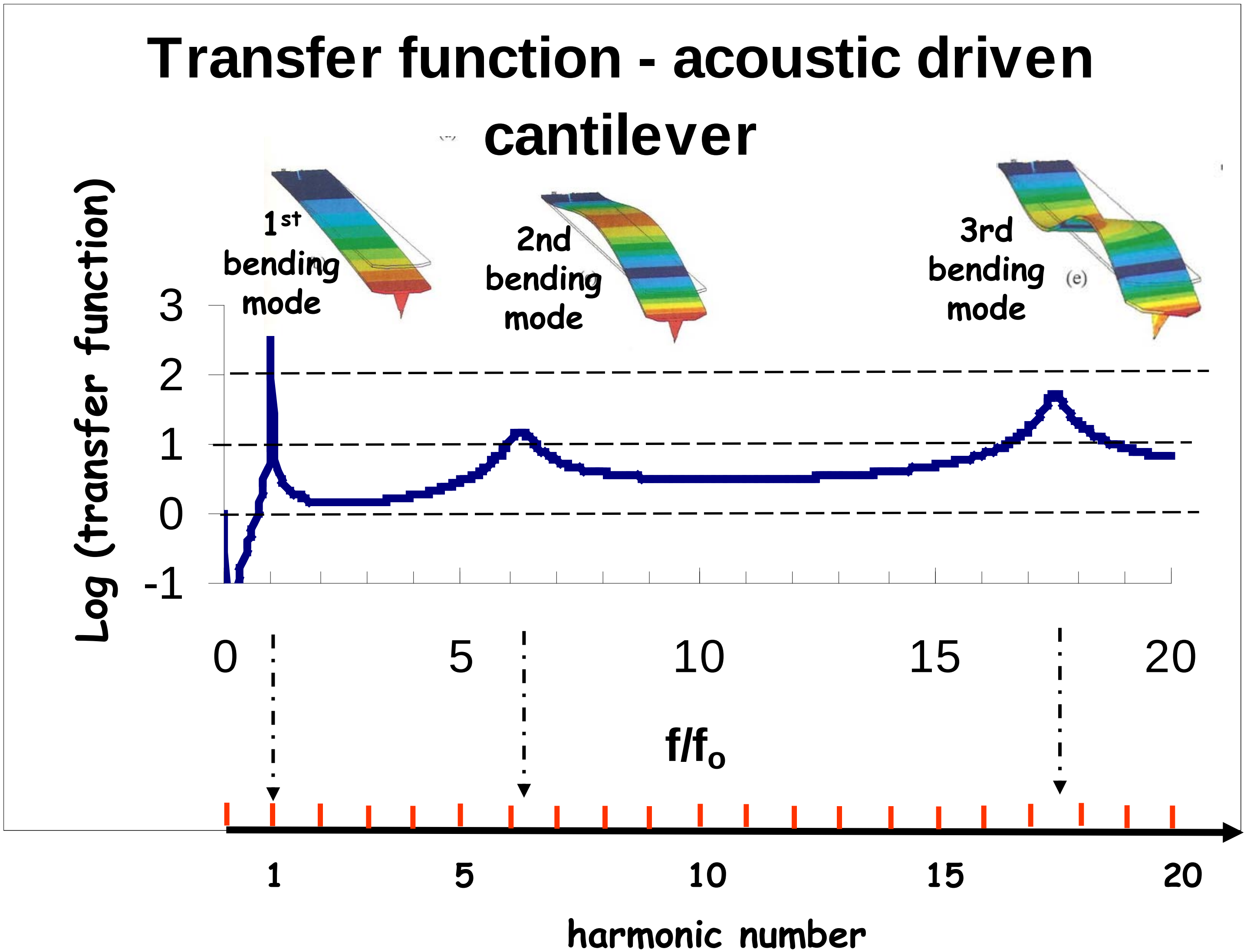
$$S(t) = \sum_{n=0}^{N} A_n \sin(2\pi n f_o t + \phi_n)$$



http://www.falstad.com/fourier/

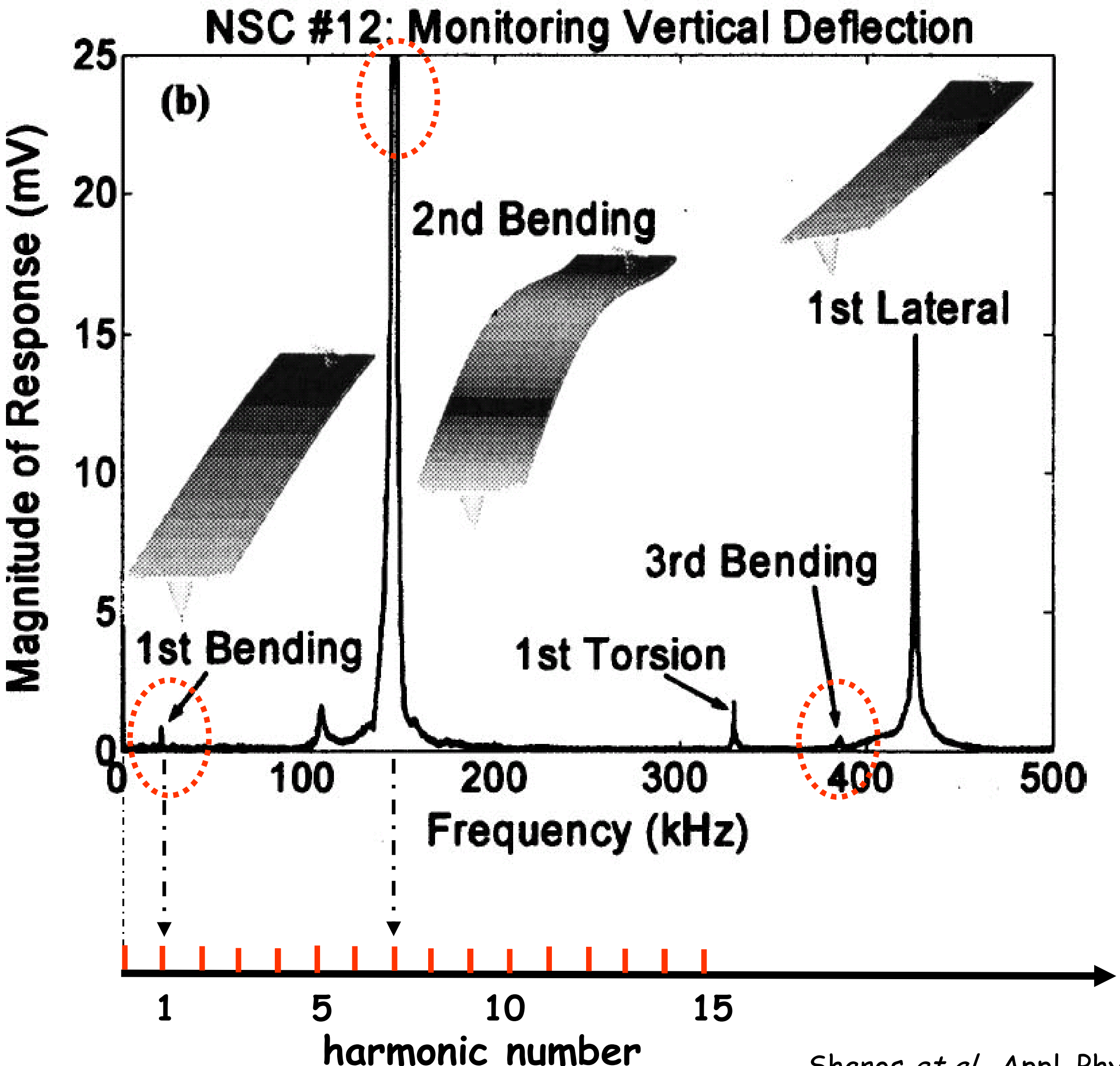
How does a cantilever respond to the harmonics?

(Acoustic excitation: Lecture 11)



Typical Cantilever Driven Vibration Spectrum
"Vibration Fingerprint"

Beware: peak heights NOT proportional to vibration amplitudes



Bending Modes:
f_1 = 21.2 kHz
f_2 = 146.3 kHz
f_3 = 386.0 kHz

Why not just pure bending modes?

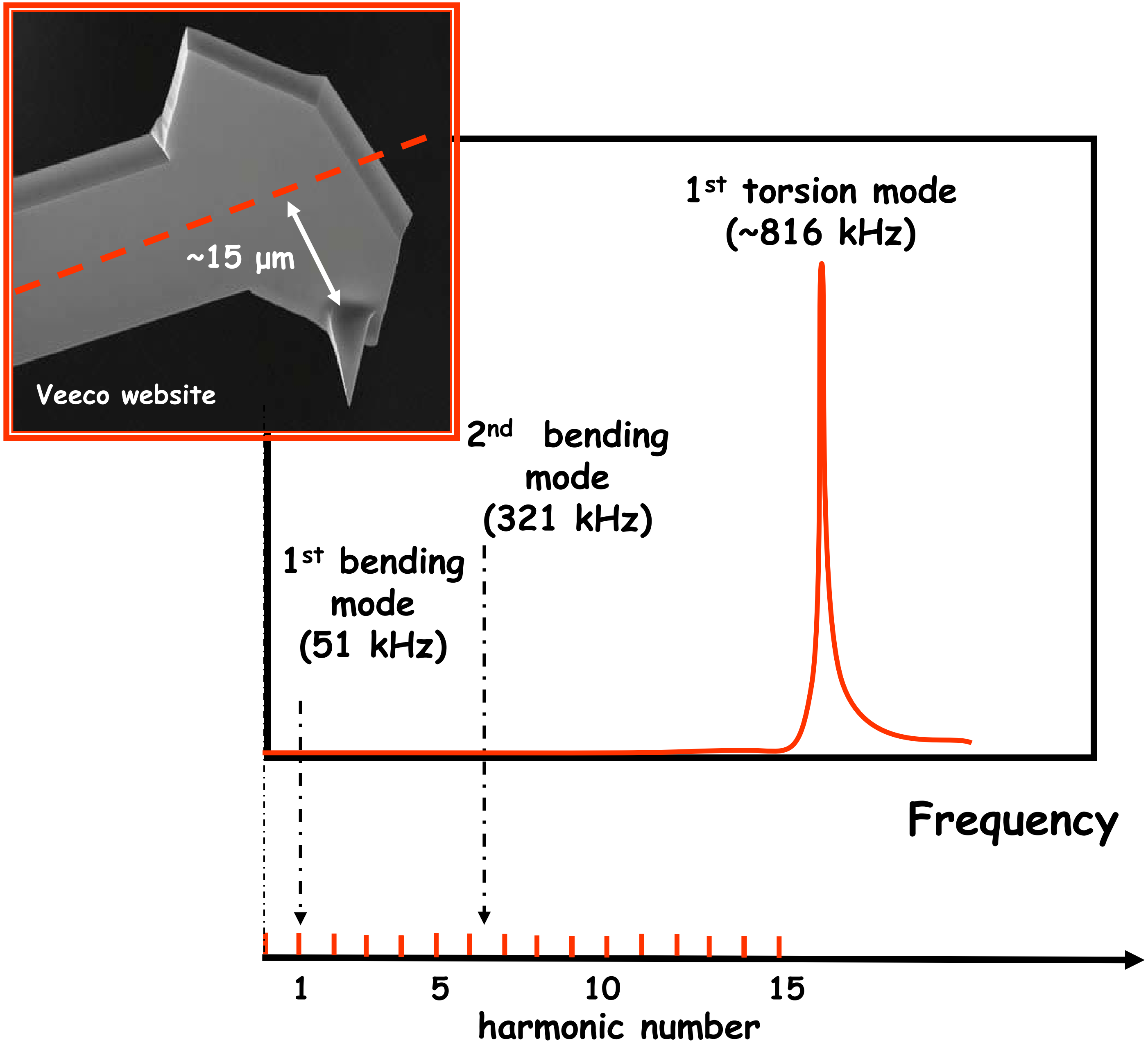
1 click

Sharos *et al.*, Appl. Phys. Lett. **84**, 4638 (2004)

Question

Can you design a cantilever/tip system that has flat response over broad frequency range?

Torsion cantilever



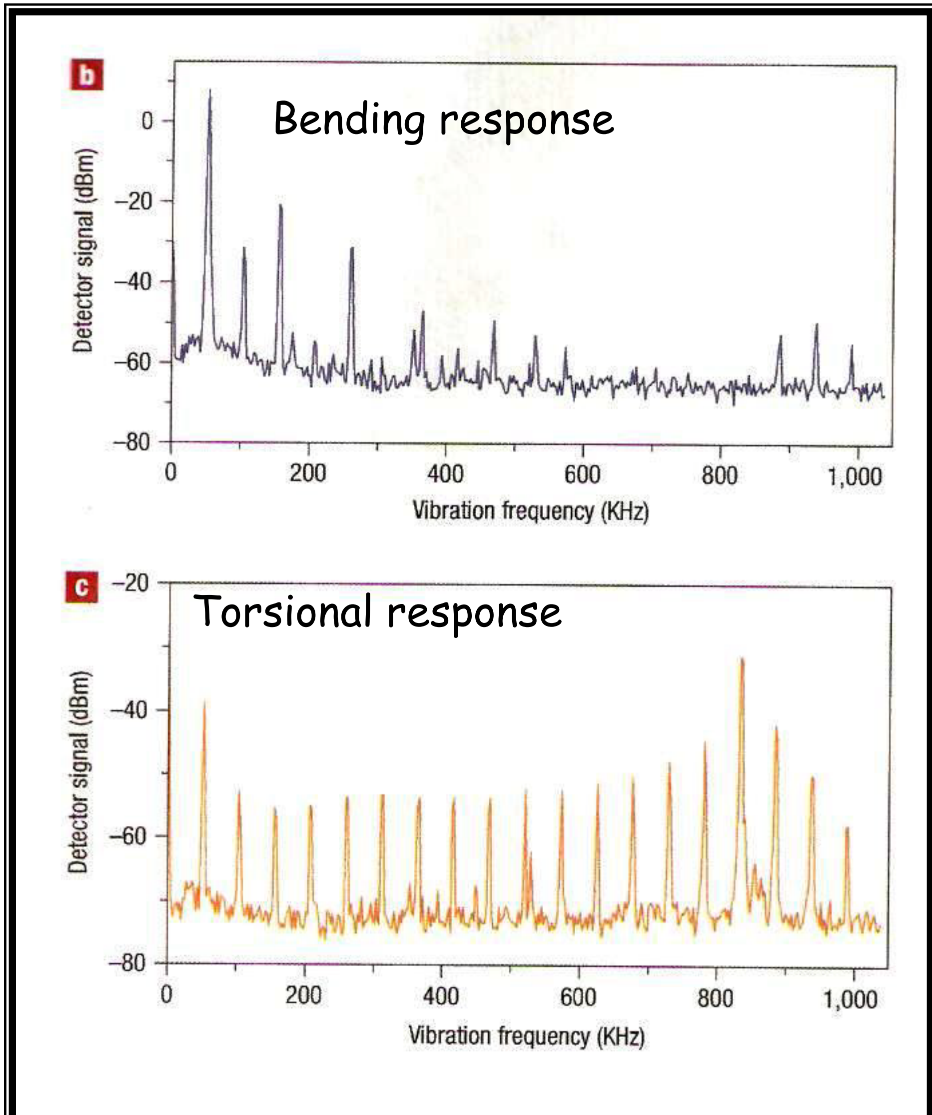
General Operation

Use first bending mode as usual to monitor topography

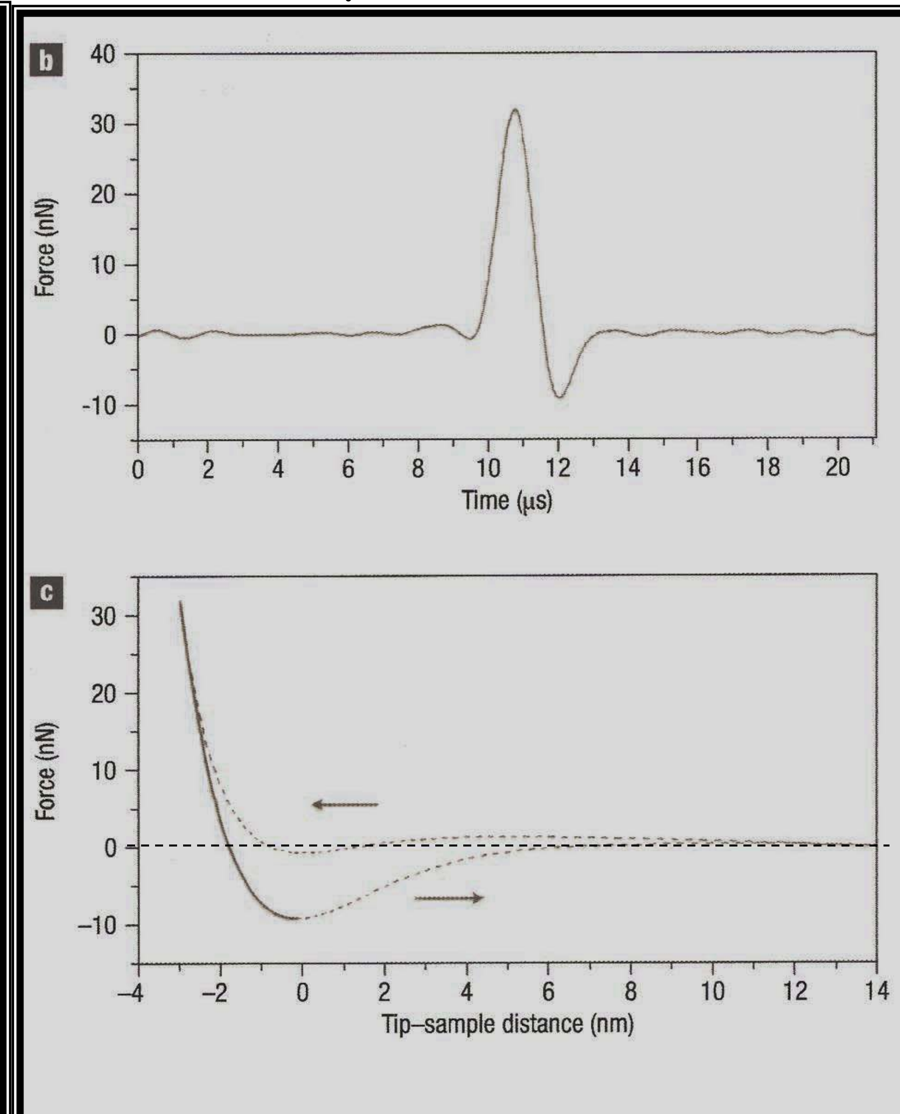
Measure harmonic spectrum using torsional mode and reconstruct tip-substrate forces <u>while scanning</u>

Results

Polystyrene Substrate

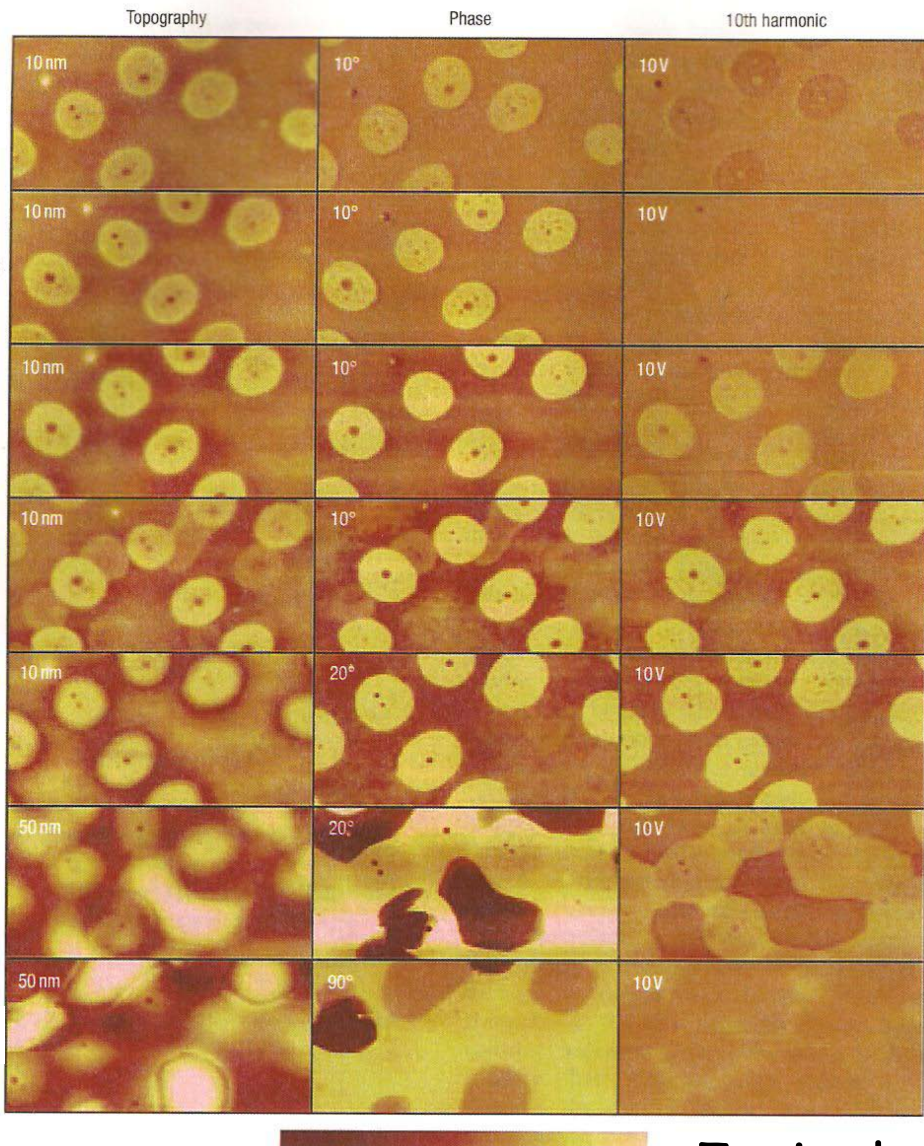


Graphite Substrate



Sahin et al., Nature **2**, 507 (2007).

50 nm thick film: PMMA in PS matrix



85° C

215° C

Increasing Temperature

Small contrast: comparable stiffness

Contrast increases: glass transition temperature

Boundaries disappear: mixing of two phases

Torsional Image

Sahin et al., Nature **2**, 507 (2007).

Concerns

Requires reliable cantilever fabrication

Is the harmonic vibrational spectrum accurately measured: non-linear coupling?

Small errors in higher harmonic estimation (either phase or amplitude) produces disastrous effects.