Simulating a Vibrating Cantilever with COMSOL

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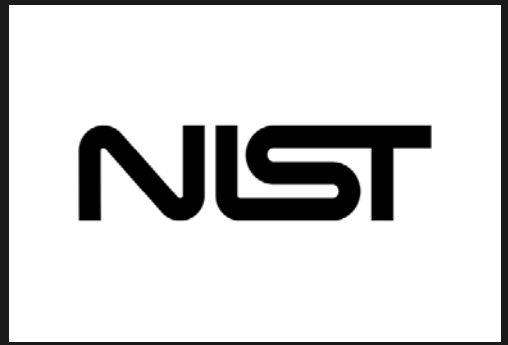
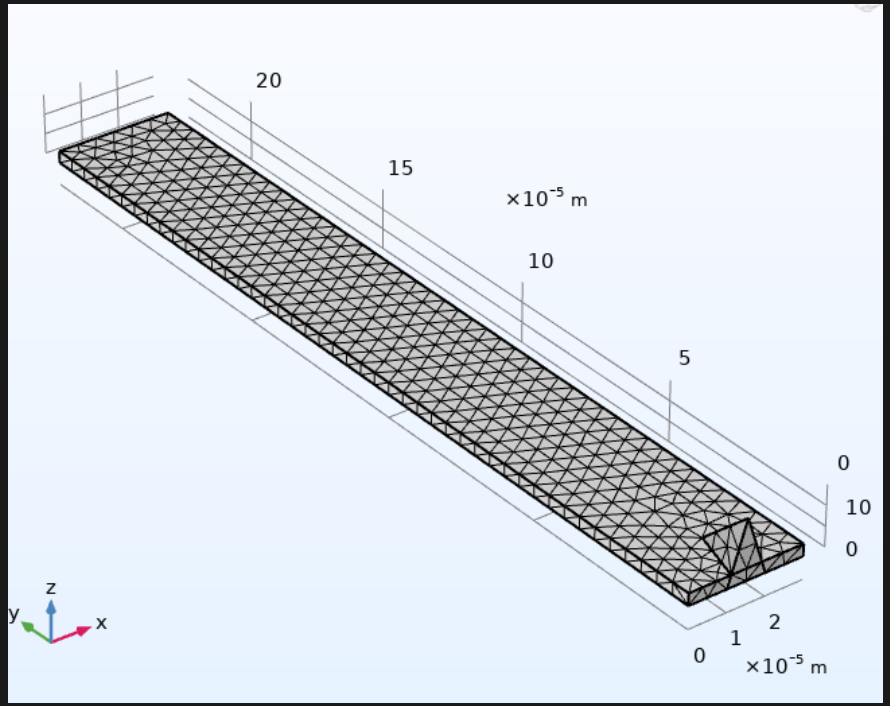


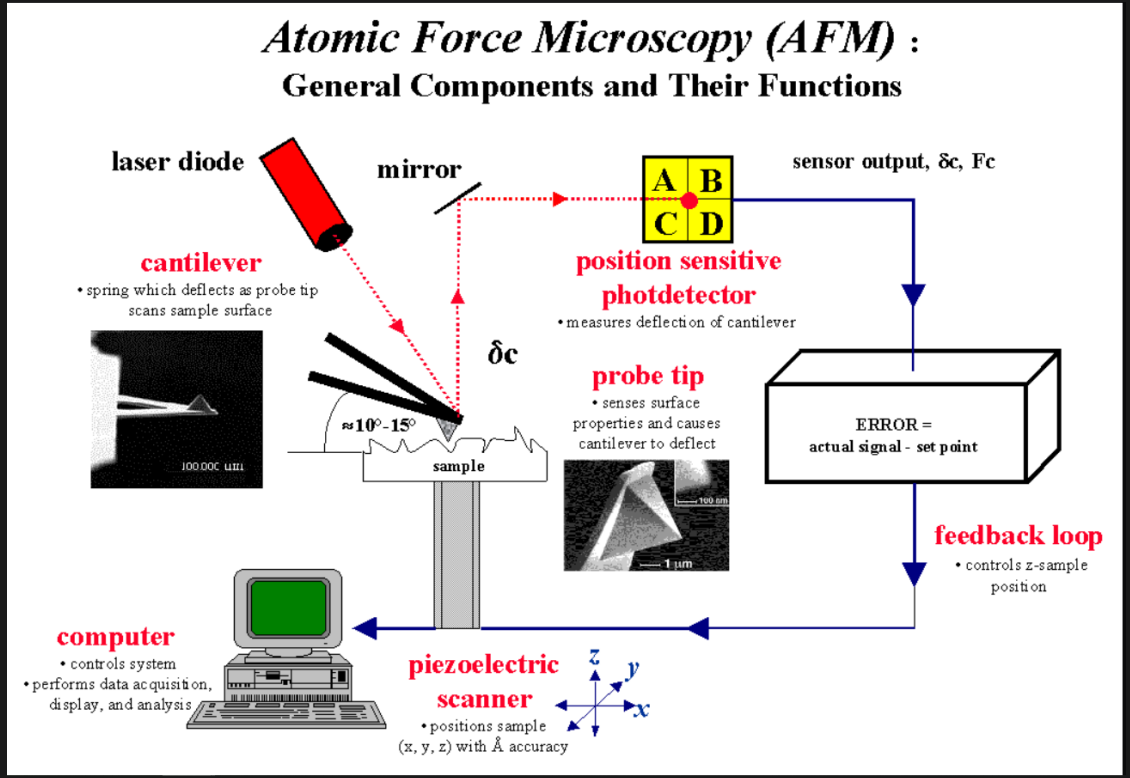
COMSOL Simulations

- COMSOL is a powerful physics simulation software
- Uses finite element analysis to solve PDE’s numerically
  - Quantum Mechanics (Schrodinger’s Equation)
  - Electricity and Magnetism (Poisson/Laplace’s Equations)
  - Thermodynamics (Heat Equation)
  - Mechanical Systems (Stress and Strain)



Atomic Force Microscopy

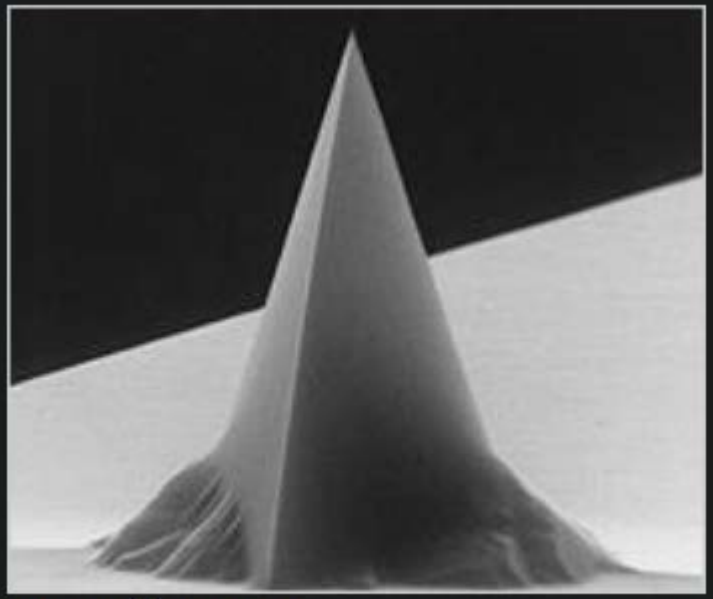
- Images material's surface
- Images surface details with sub-nanometer resolution ~ 1000+ times better than optical
- Measures Van der Waals atomic forces



http://lnf-wiki.eecs.umich.edu/wiki/Atomic_force_microscopy

Operational Modes of AFM

- Contact AFM
  - Interaction forces are mostly repulsive in this regime due to electron repulsion
- Non-contact AFM
  - Tip hovers 10-150 [A] above sample, scanned across.
  - Offers the advantage of measuring sensitive (soft) materials
- Tapping AFM
  - Combines both so that sensitive materials are protected and resolution is better

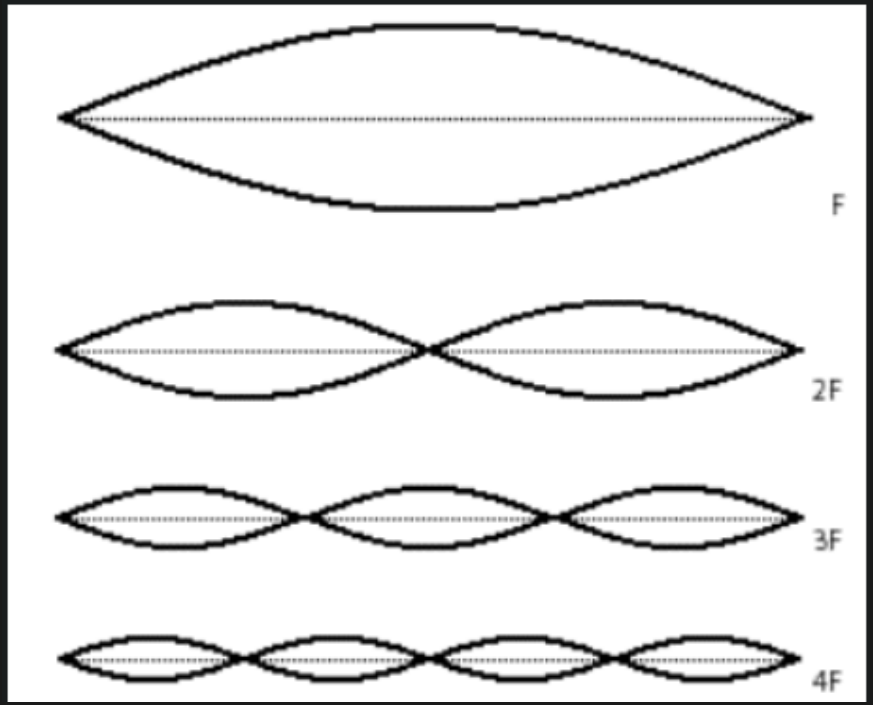


Point Probe AFM tip

https://www.nanoworld.com/pointprobe-electrostatic-force-microscopy-afm-tip-efm

Resonance and Eigenmodes of Cantilever

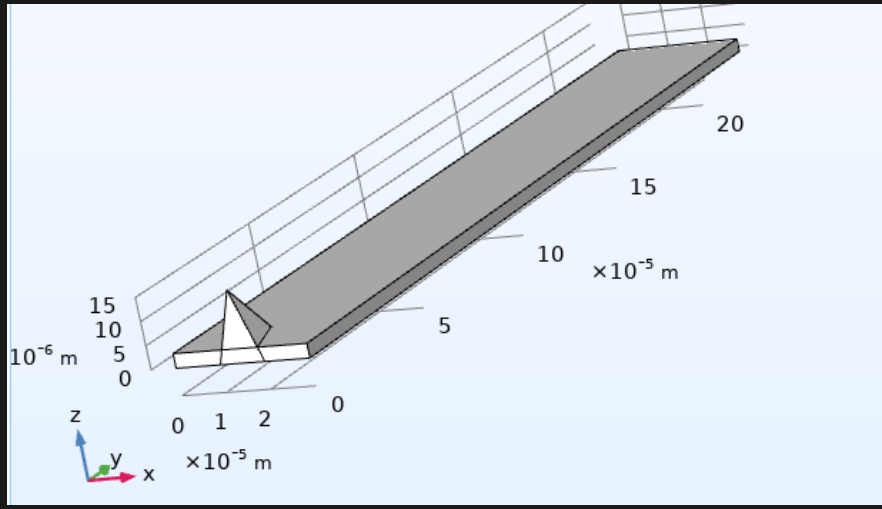
- Resonance of the cantilever-tip system is an important aspect of non-contact and tapping mode AFM.
- Thus, it is useful to see the modes of oscillations, and their corresponding frequency for a given material and geometry



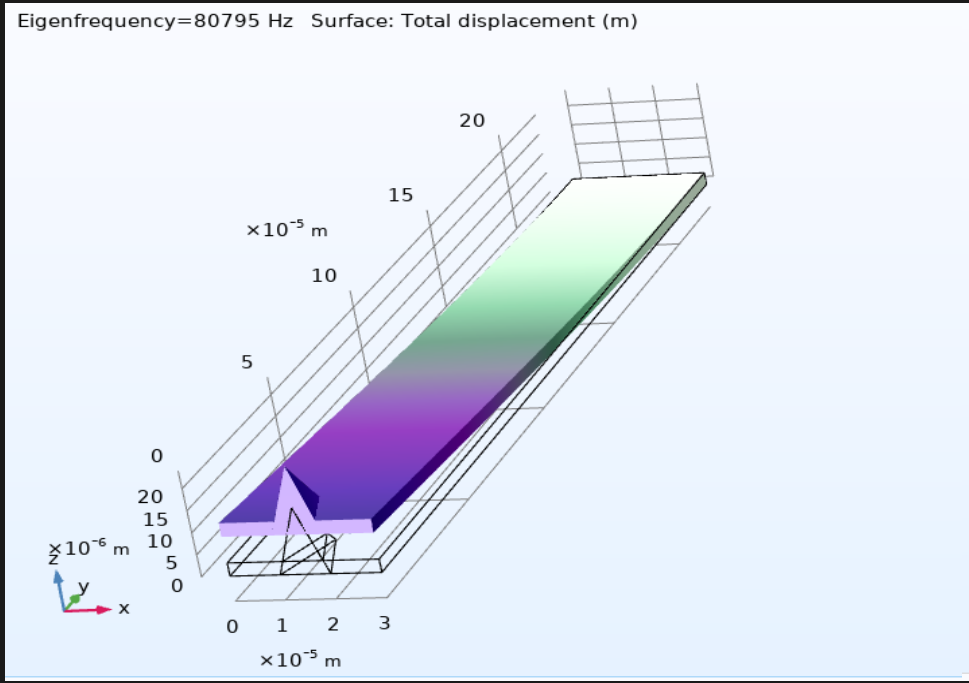
https://wtt.pauken.org/chapter-1/strings-and-air/2

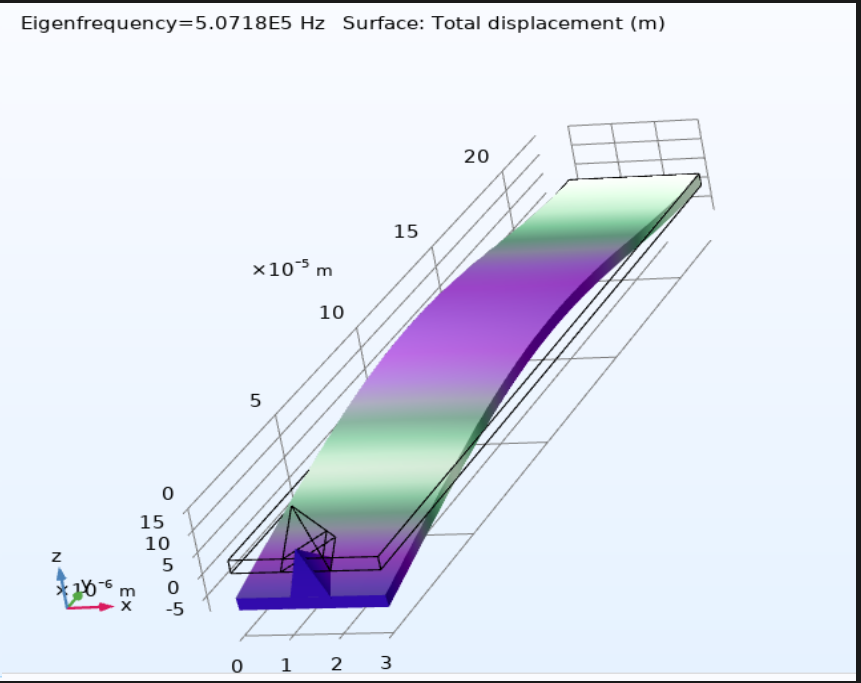
Cantilever in COMSOL

- Cantilever geometry is 30 μm in width, 225 μm in length and 3 μm in thickness
- The material is p-type Silicon with a Platinum undercoating
- A point load of 0.6 nN is applied to the tip of the cantilever

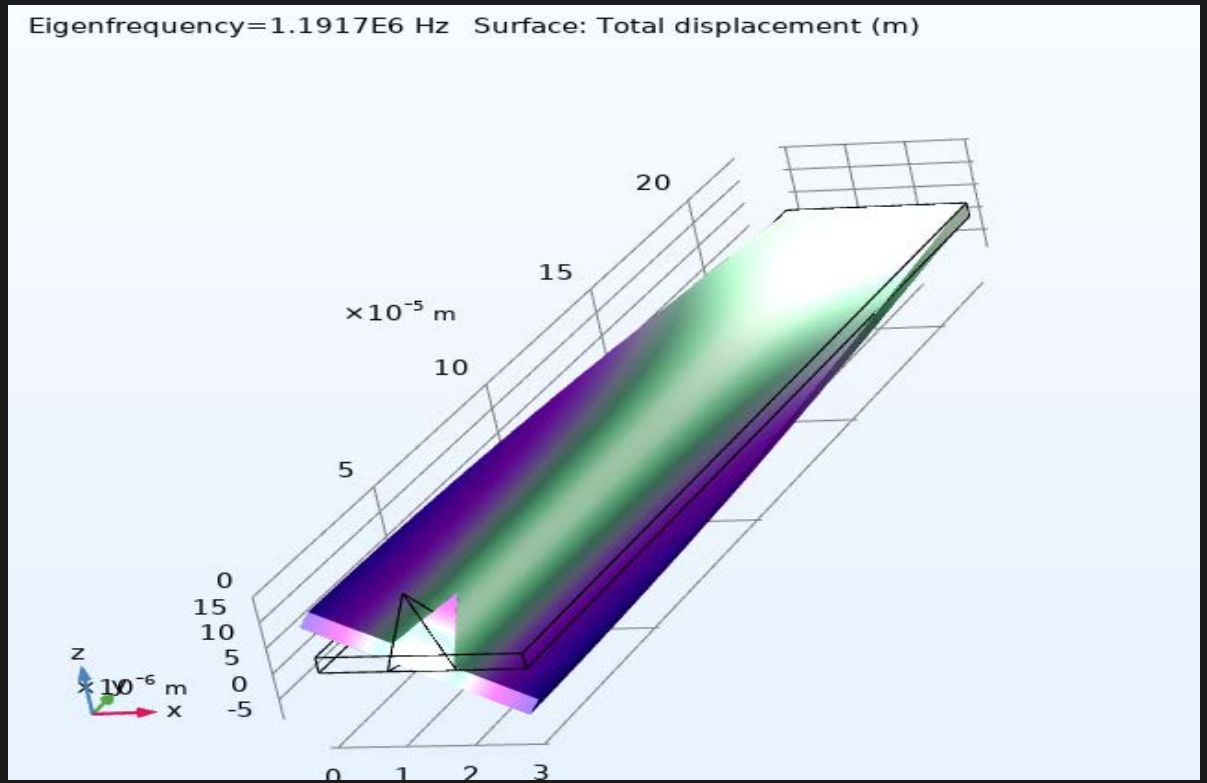


Vibrational Modes





Torsional Mode



Acknowledgments

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