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Abstract
Atomic force microscopy (AFM) is an imaging technique used to determine topography and other properties of surfaces. It is an important tool for nanoscience.

What is a nanometer?
A nanometer, the unit of length associated with nanoscience, is one billionth of a meter. The ratio of a nanometer to a meter is the same as that of one millimeter to the distance between Worcester and Detroit.

How does AFM work?
There are four principal kinds of operational modes according to the separation between the cantilever and the surface, the cantilever’s oscillation amplitude, and the normal or torsional bending of the cantilever. Many other variations also exist.

Advantages and disadvantages of AFM
- Easy sample preparation
- Accurate height information
- Works in vacuum, air, and liquids
- Living systems can be studied
- Limited vertical range
- Limited magnification range
- Data not independent of tip
- Tip or sample can be damaged

Ways of using AFM
- Imaging — determining the topography of the surface
- Measuring — characterizing the sample’s materials properties
- Manipulating — purposefully changing the surface structure
- Sensing — using AFM technology for sensor applications

What is AFM used for?
Imaging — The AFM can be used to construct a picture of a CD stamper (left) or human chromosomes (right).

Measuring — Carbon nanotubes are rolled-up sheets of graphite and have valuable electronic and mechanical properties. The left image reflects the topography of a nanotube near a step on a mica surface. To create the image on the right, the AFM scanner oscillated laterally a small amount and the resulting oscillation of the cantilever was monitored, reflecting the amount of shear between the tip and the sample.

Sensing — A microcantilever bends in response to chemical adsorption. Based on this principle, AFM is used to “smell” different substances (such as whisky) in order to establish their composition.

Manipulating — Using 1024 cantilevers, the “Millipede” can write on a surface of polymer film. The actuators (dark blue) move the polymer-coated substrate in the xy-plane beneath the cantilever array. Each cantilever is individually controlled and can produce or erase a small pit that represents a bit of information. It is predicted that 100 GB of memory can be put on only one square inch using this technology.