# Atomic Force Microscope (AFM)

**Introduction** → The atomic force microscope was invented in 1986 by Binning and Gerber.

Similar to the other scanning probe microscope, the AFM, raster scans a sharp probe over the surface of a sample and measures the change in force between the probe tip and sample.

**Working concept** → The physical parameter probed is a force resulting from different interaction. The origin of these interaction can be ionic repulsion, vander waals, capillary, electrostatic and magnetic force or elastic and plastic deformation. Thus an AFM image is generated by recording the force change as the probe (or sample) is scanned in x and y directions.

The sample is mounted on a piezo electric scanner which ensure three dimensional positioning with high resolution. The force is monitored by attaching the probe to a pliable cantilever, which acts as a spring and measuring the bending and deflection of cantilever.

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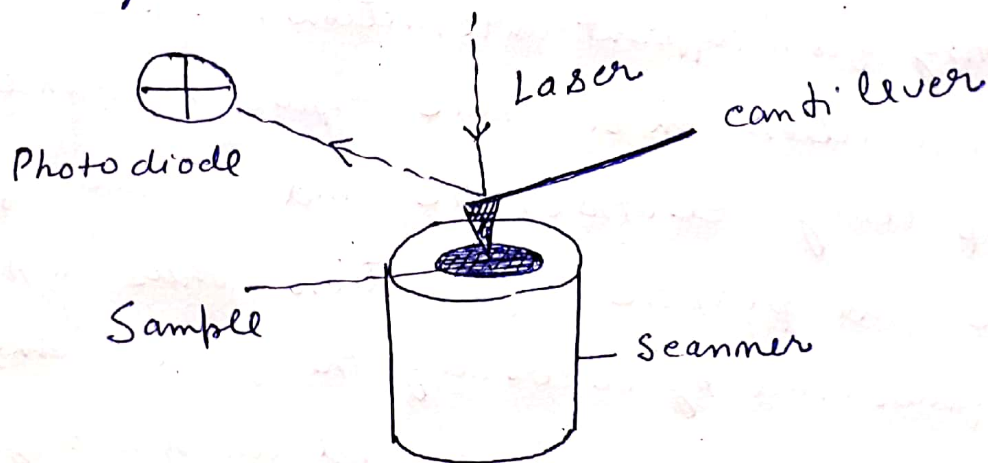
The Larger the cantilever deflection, higher the force that will be experienced by the probe. Most instruments today use an optical method to measure the cantilever deflection with high resolution. A Laser beam is focused on the free end of the cantilever and the position of the reflected beam is detected by a position-sensitive detector (Photodiode). AFM cantilever and probes are made of silicon or silicon nitride by microfabrication technique.




Basic Set-up of an AFM →

In Principle the AFM resembles a record player and a stylus profilometer. The ability of an AFM to achieve near atomic scale resolution depend on the three essential component.

1. A cantilever with a sharp tip
2. A scanner with x-y control
3. Feedback control and loop

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1. <u>Cantilever with a sharp tip</u> → The stiffness of the cantilever needs to be less the effective spring constant holding atom together, which is on the order of 1-10 mN/mm. The tip should have a radius of curvature less than 20-50 mm (smaller is better) a cone angle between 10-20 degrees.

2. <u>Scanner</u> → The moment of the tip or sample in the x-y and z direction is controlled by a piezo-electric tube scanner. For typical AFM scanner the maximum range are 80mm x 80mm in x-y plane and 5mm for the z-direction.

3. <u>Feed back control</u> → The force between the tip and the sample measured by the ~~amount of~~ bending of the cantilever. By calculating the difference signal in the photo diode quardants, the amount of deflection can be correlated with height. Because the cantilever obey Hook's Law for small displacement the interaction force between the tip and the sample can be determine.

AFM Mode of operation

| Mode of operation | Force of interaction |
|---|---|
| Contact mode | Strong (repulsive) - const force or distance |
| Non-Contact mode | weak (attractive) - vibrating probe |
| Tapping mode | Strong (replusive) - vibrating mode |
| Lateral force mode | Frictional forces exert a torque on the scanning cantilever |

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