Atomic Force Microscopy (AFM)

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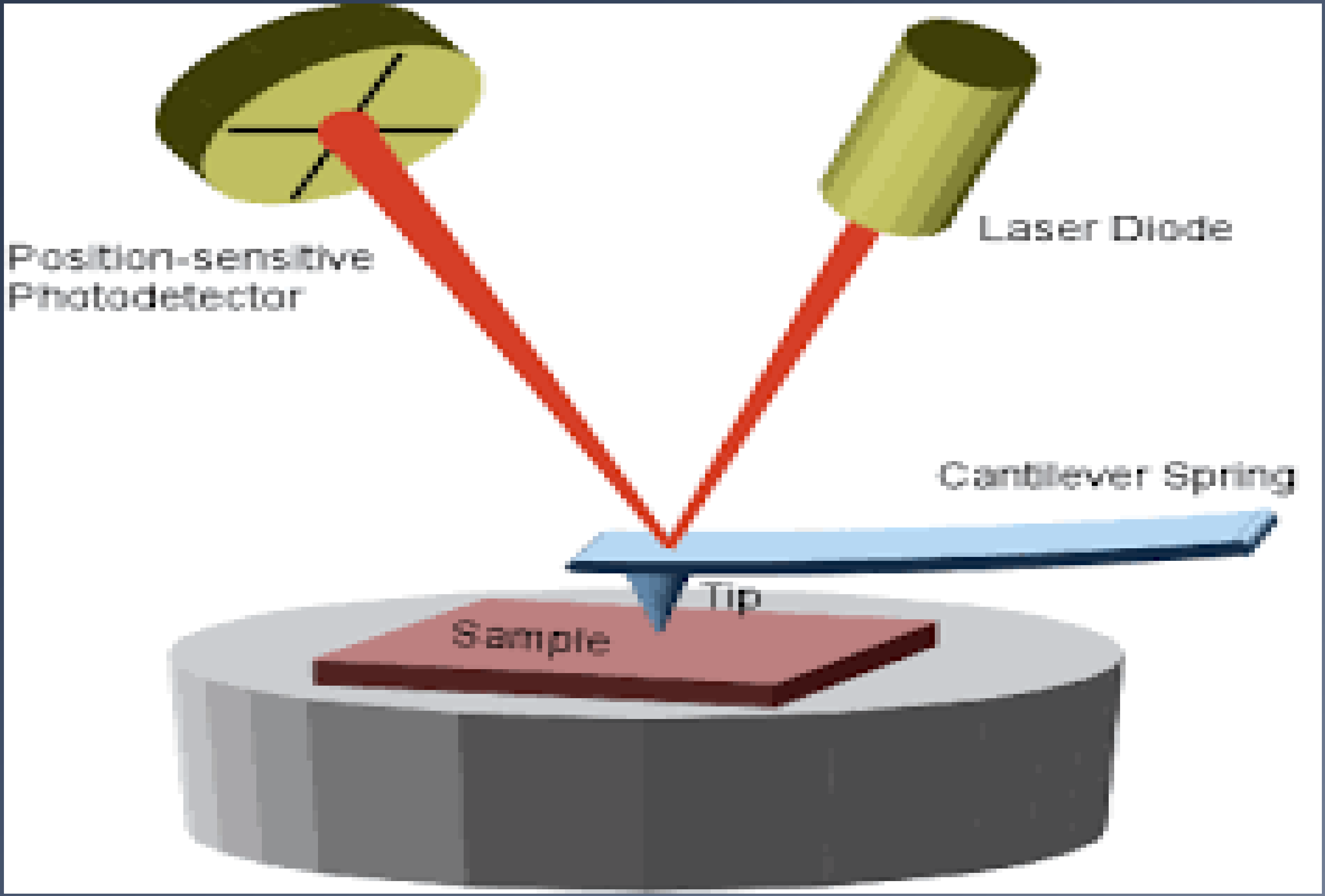

Position-sensitive
Photodetector
Laser Diode
Cantilever Spring
Tip
Sample

Applications

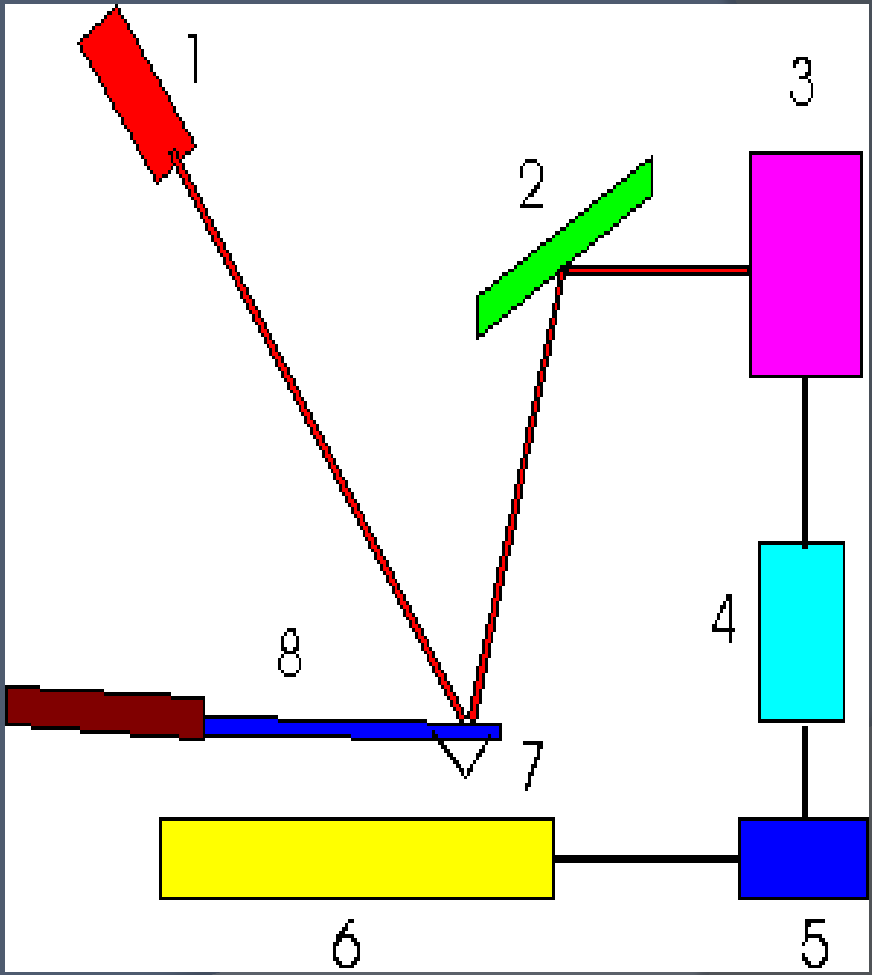
- in all materials like: Thin and thick film coatings, ceramics, composites, glasses, synthetic and biological membranes, metals, polymers, and semiconductors.
- Used to study phenomena of: cut, bond, cleaning, corrosion, drawing, resistance, lubricating, plating, and polishing.
- AFM can image surface of material in atomic resolution and also measure force at the nano-Newton scale.

Background and History

- 1st AFM made by (Gerd Binnig) and (Cristoph Gerber) in 1985
- Constructed by gluing tiny shard of diamond onto one end of tiny strip of gold foil
- Small hook at end of the tip pressed against sample surface
- Sample scanned by tracking deflection of cantilever by monitoring tunneling current to 2nd tip position above cantilever
- Developed in order to examine insulating surfaces

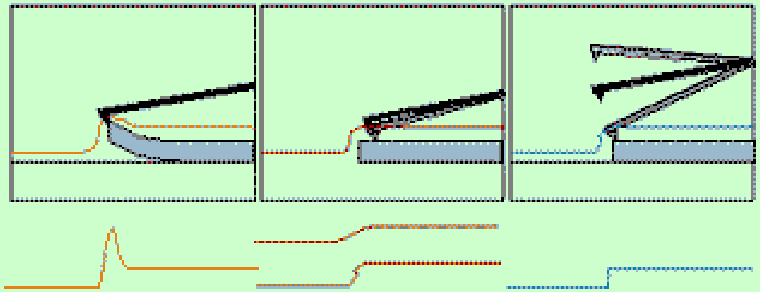
Parts of AFM

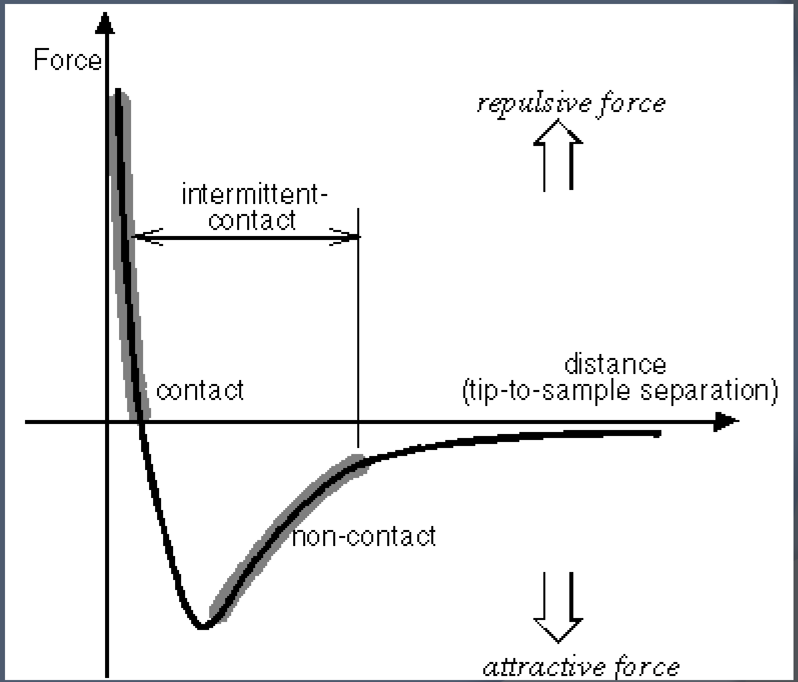
- 1. **Laser** – deflected off cantilever
- 2. **Mirror** –reflects laser beam to photo detector
- 3. **Photo detector** –dual element photodiode that measures differences in light intensity and converts to voltage
- 4. **Amplifier**
- 5. **Register**
- 6. **Sample**
- 7. **Probe** –tip that scans sample made of Si
- 8. **Cantilever** –moves as scanned over sample and deflects laser beam



3 Modes of AFM

1. Contact Mode
2. Non-Contact Mode
3. Tapping (Intermittent contact) Mode





1.Contact Mode

- Measures repulsion between tip and sample
- Force of tip against sample remains constant
- Feedback rule keeps cantilever deflection constant
- Voltage required indicates height of sample
- Problems: great tracking forces applied by probe to sample

2.Non-Contact Mode

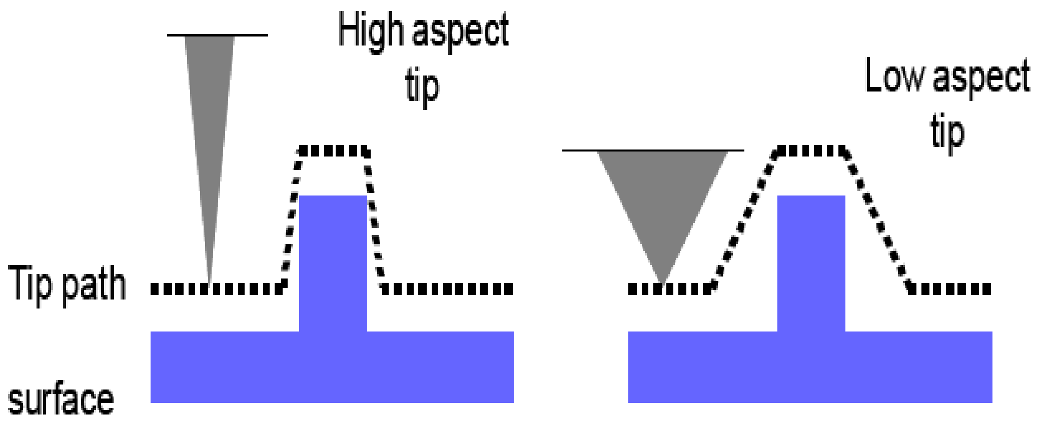
- Measures attractive forces between tip and sample
- Tip doesn’t touch sample
- Van der Waals forces between tip and sample detected
- Problems: Can’t use with samples in fluid
- Used to analyze semiconductors
- Doesn’t degrade or interference with sample- better for soft samples

3.Tapping (Intermittent-Contact) Mode

- Tip vertically oscillates between contacting sample surface and lifting of at frequency of 50,000 to 500,000 cycles/sec.
- Oscillation amplitude reduced as probe contacts surface due to loss of energy caused by tip contacting surface
- Advantages: overcomes problems associated with friction, adhesion, electrostatic forces
- More effective for larger scan sizes

What are the limitations of AFM?

- AFM imaging is not perfectly quick



Ideally a probe (tip) with a high aspect ratio will give the best resolution. The radius of curvature of the probe leads to tip convolution. This does not often influence the height of a feature but the lateral resolution.

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

The Future of Atomic Force Microscopy

- Sharper tips by improved micro production processes: tip – sample interaction tends to deform soft biological molecules
- Atomic or angstrom resolution images of live cell surfaces: development of more flexible cantilever springs and less damaging and non sticky probes needed


Ara-A.F.M.
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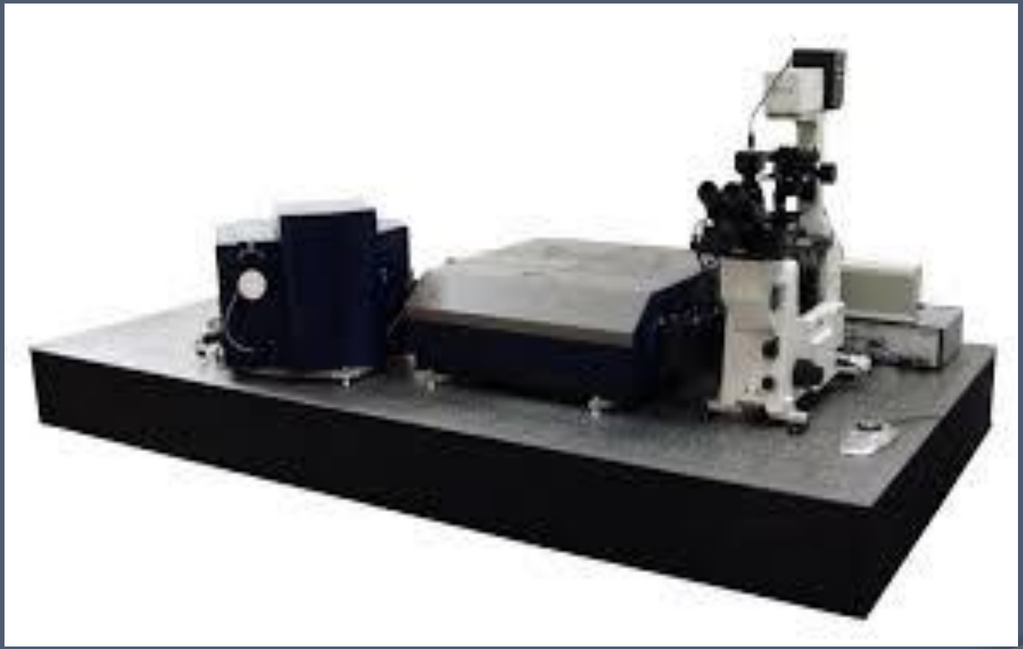
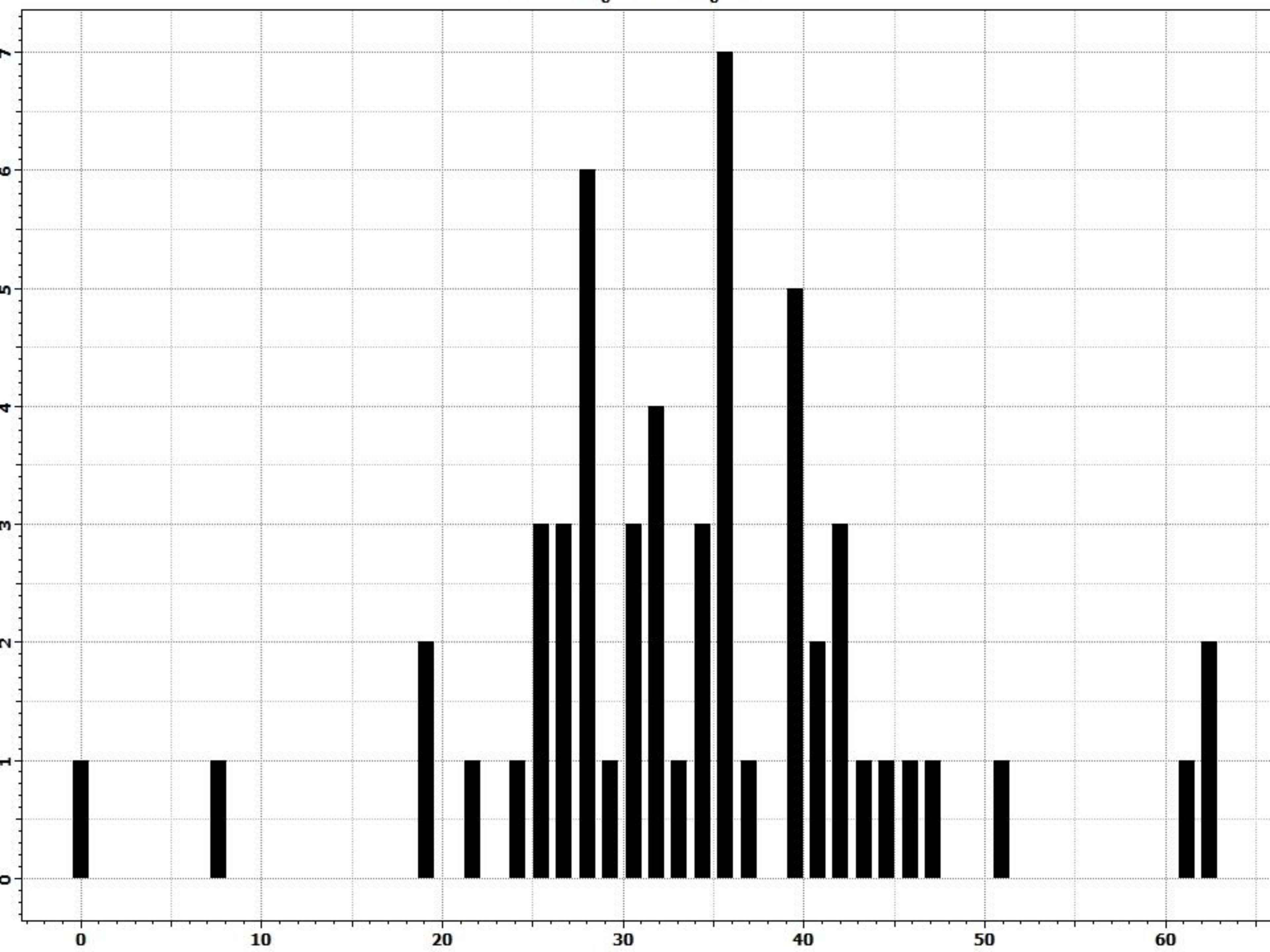
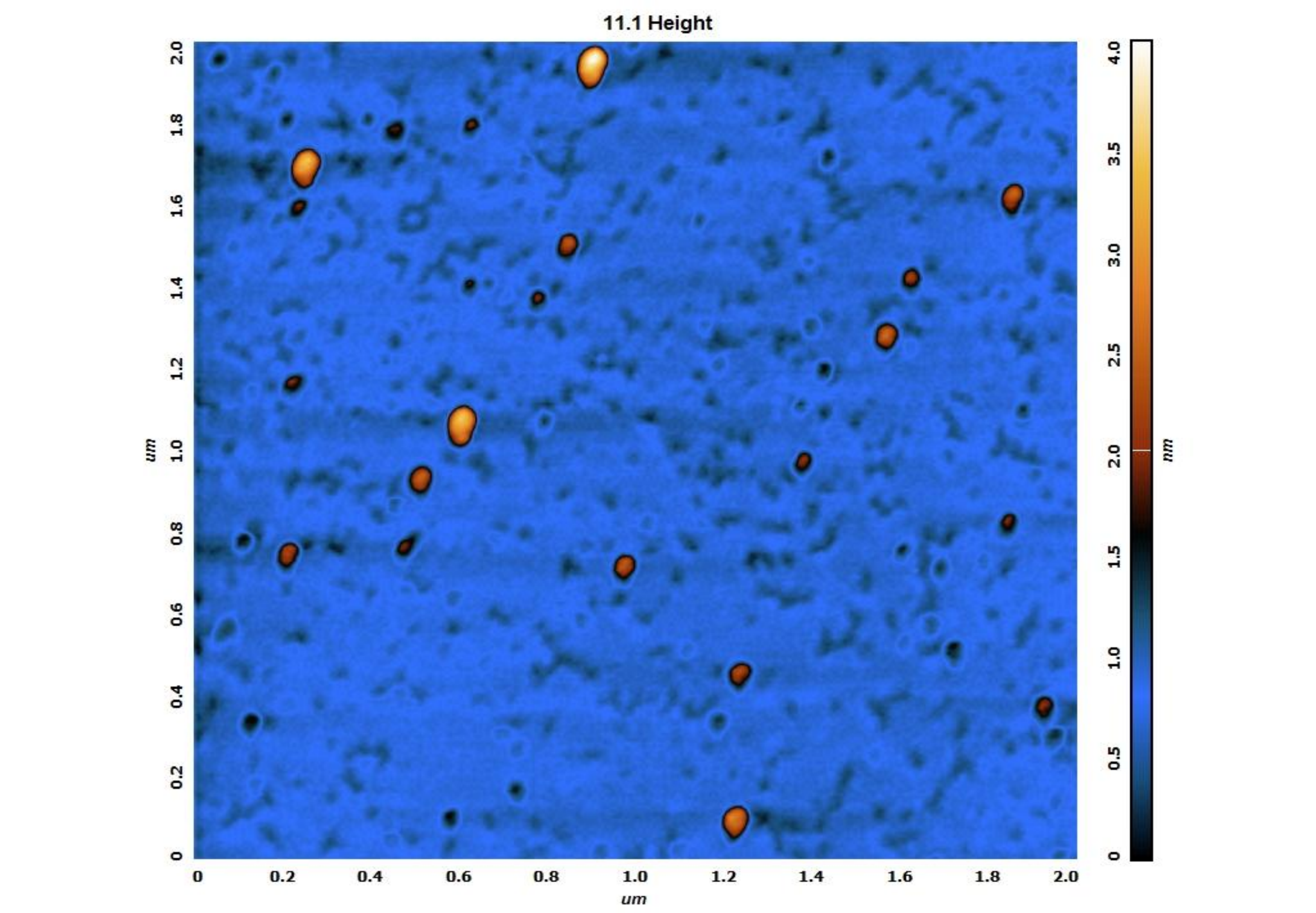




0
1
2
3
4
5
6
7
0
10
20
30
40
50
60


11.1 Height
um
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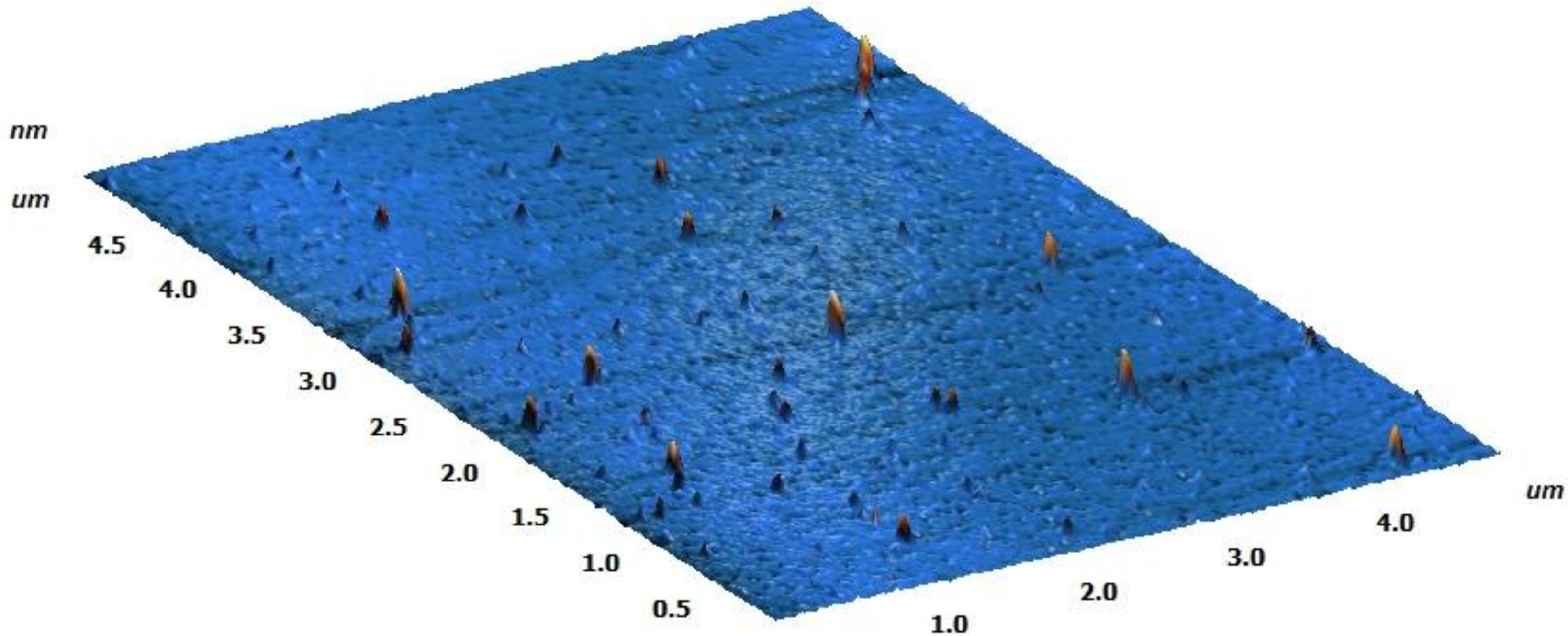
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
nm
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0



nm
um
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1.0
2.0
3.0
4.0
um

References

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