
Introduction to Nanomaterial and Nanotechnology

Graduate Seminar 730

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Outline

- 1. What's nanomaterial?
 - 2. Why do we research nanomaterial?
 - 3. How to research nanomaterial?
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- *“ The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom.”*
“Put the atoms down where the chemist says, and so you make the substance.”



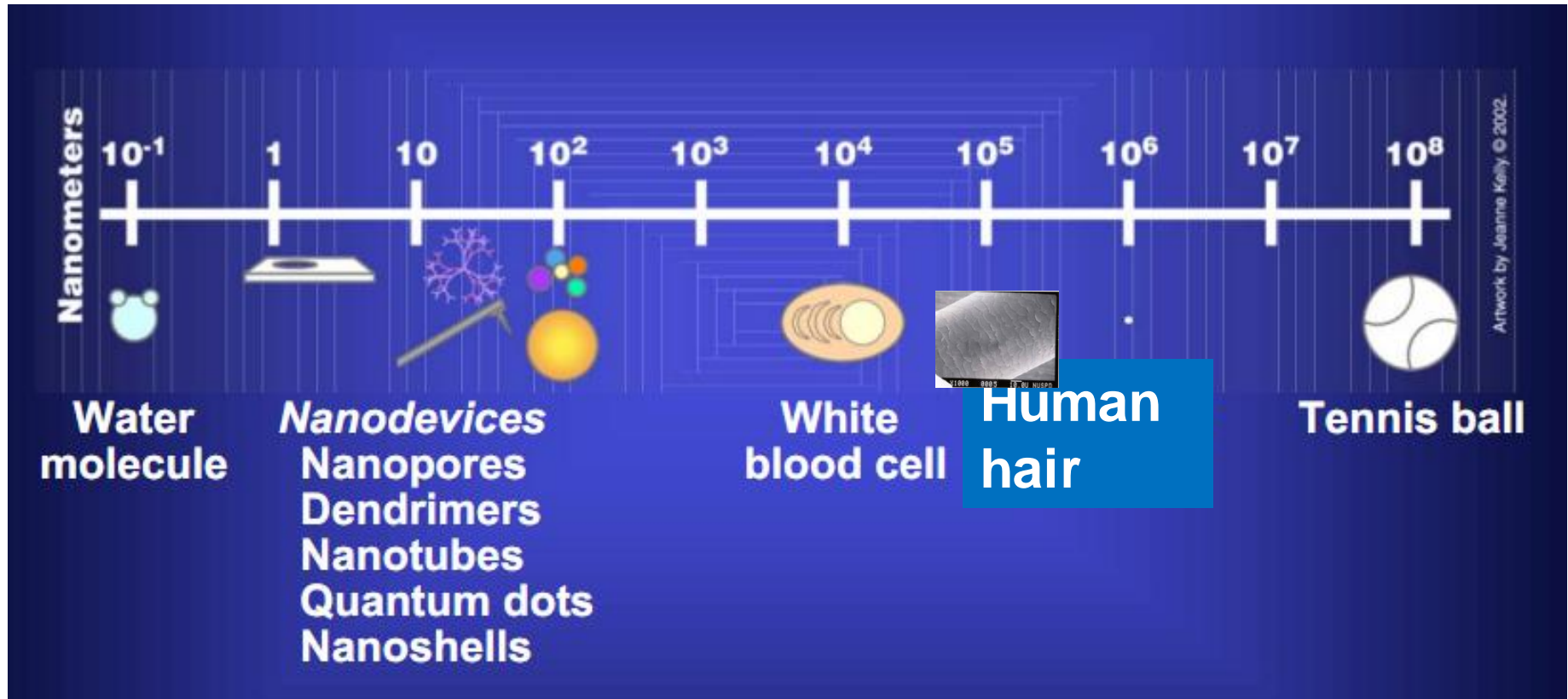
- Richard Feynman(1959)
There's Plenty of Room at the Bottom

1. What is nanomaterial?

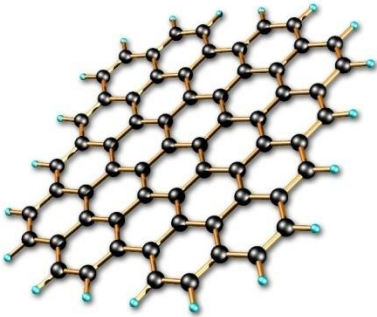
- Nanoscale : generally refers to the size scale of 1 – 100 nm in at least one dimension.

$$1 \text{ nanometer (nm)} = 10^{-9} \text{ m}$$

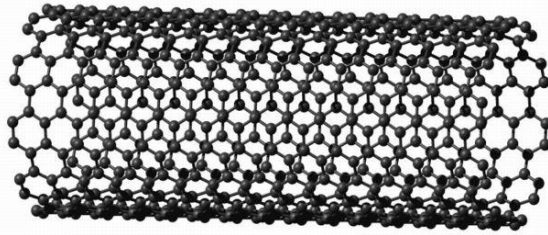
How small is 1 nanometer?



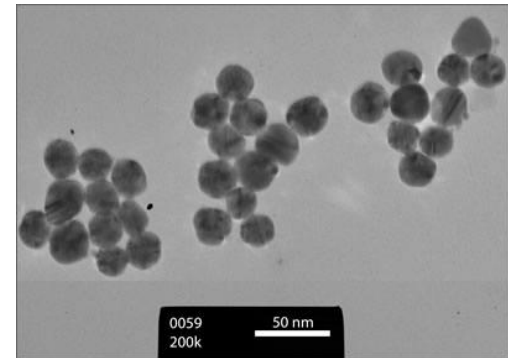
- Nanomaterial: if the length scale of the matter, in any dimension, is approximately 1 to 100 nanometers, it can be called nanomaterial.



1 dimension

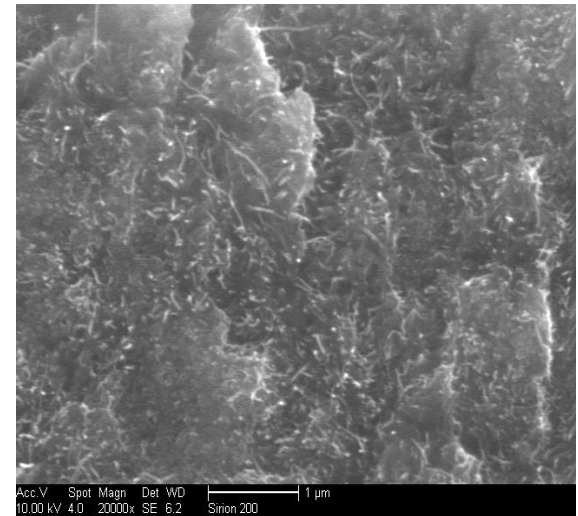
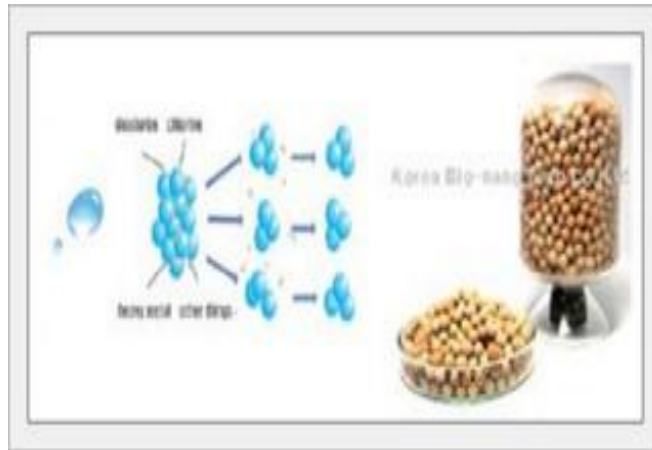


2 dimensions



3 dimensions

- Nanomaterials can be metals, ceramics, polymeric materials, or composite materials.



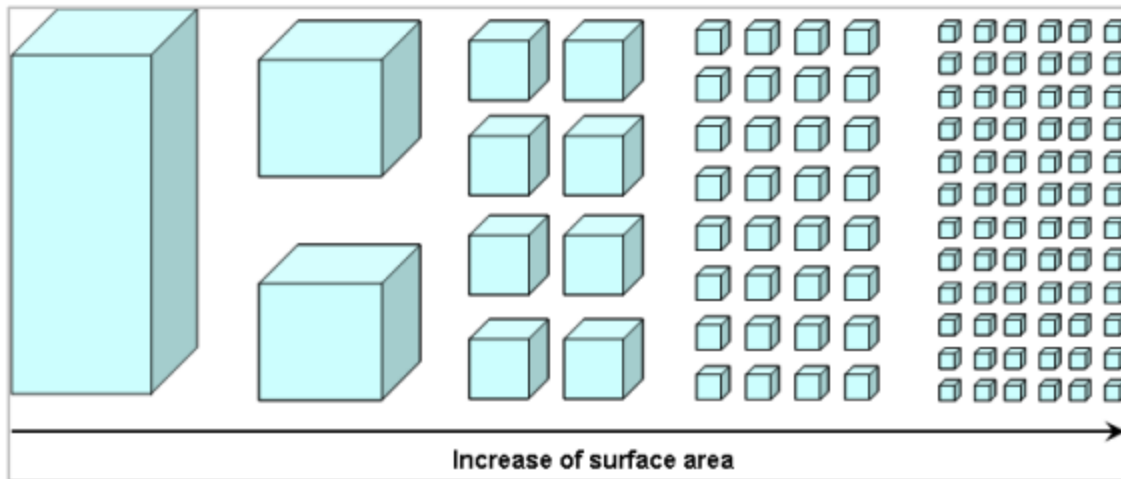
2. Why do we research nanomaterial?

- Small size effect (Quantum size effect)
 - Contain very small number of atoms(molecules)
 - Electronic states are quite different from those of bulk. Discrete energy levels

Quantum Mechanics

- Large surface effect:

- The vastly increased ratio of surface area to volume.

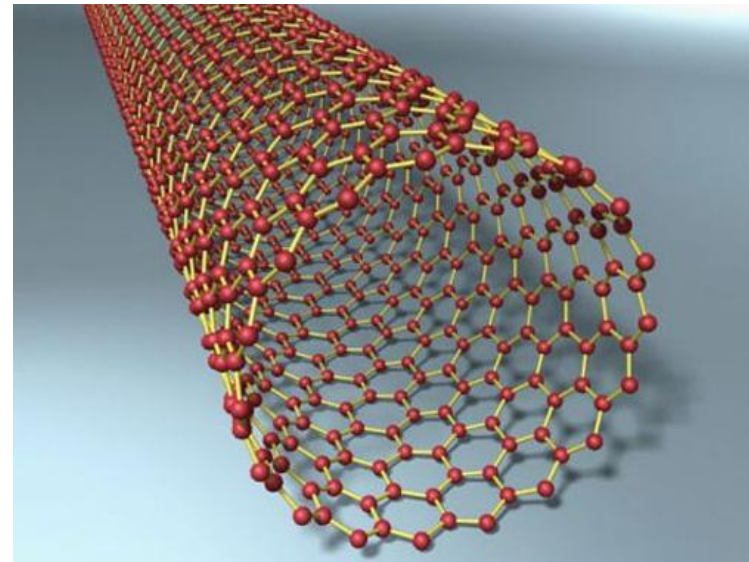
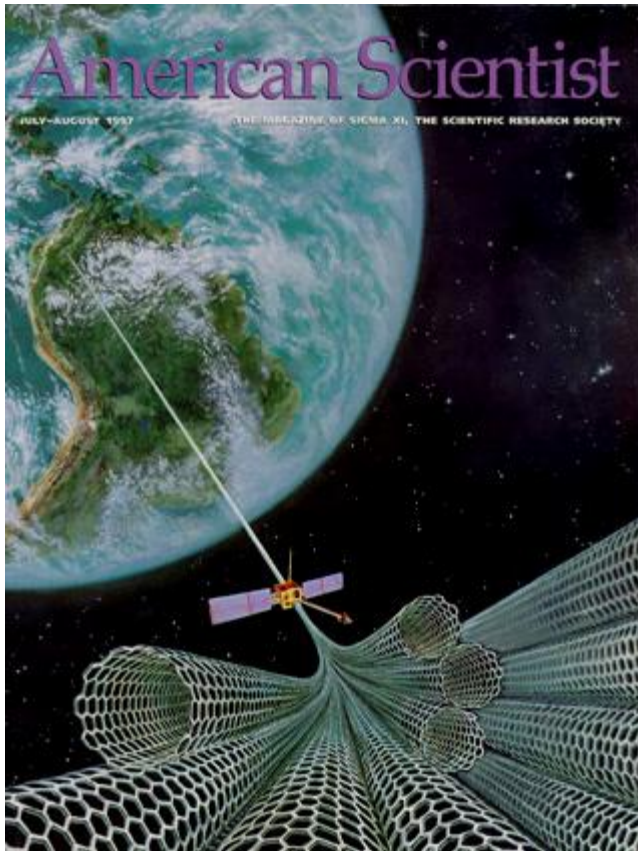


If a bulk material is subdivided into an ensemble of individual nanomaterials, the total volume remains the same, but the **collective surface area is greatly increased**. This is schematically shown in **Figure 3**.

Novel property



a piece of gold to be golden in colour however big or small it is. This is correct at the macro and micro-scale level; but at the nanoscale things start to change dramatically, due to quantum effects. Precisely gold can be used as a prime example: a colloid of gold nanoparticles is no longer “golden” but ruby red in colour



**200 times stronger than steel
of the same diameter.**

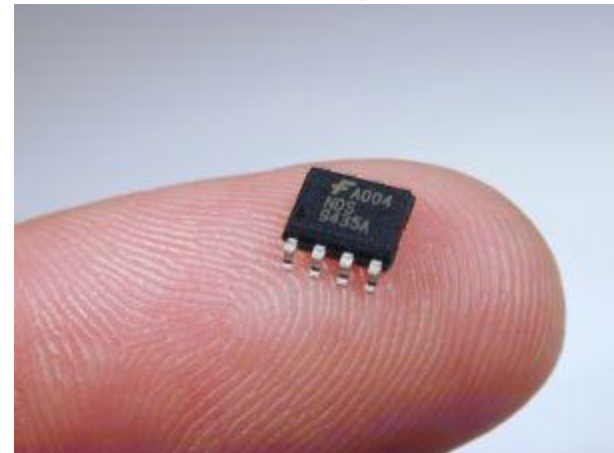
Space elevator idea is not complicated, its principle is through a 100,000km long super-human strength of the cable into space, one end of the cable located on the earth, one end located on satellite.

Nano-electronics

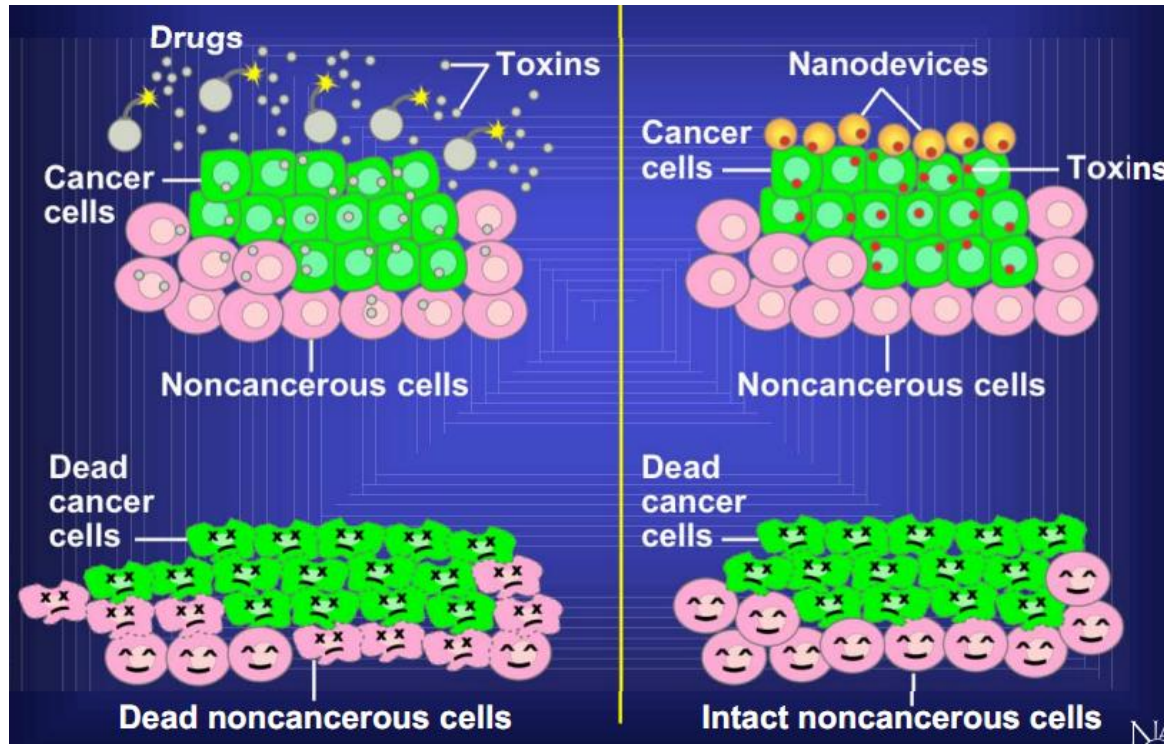
- Moore's law

If the number of chips keeps on increasing, more heat, excessive leakage current.

- Excellent conductors of electricity and heat
much smaller, lower power consumption,
faster calculation.



■ Nano-medicine

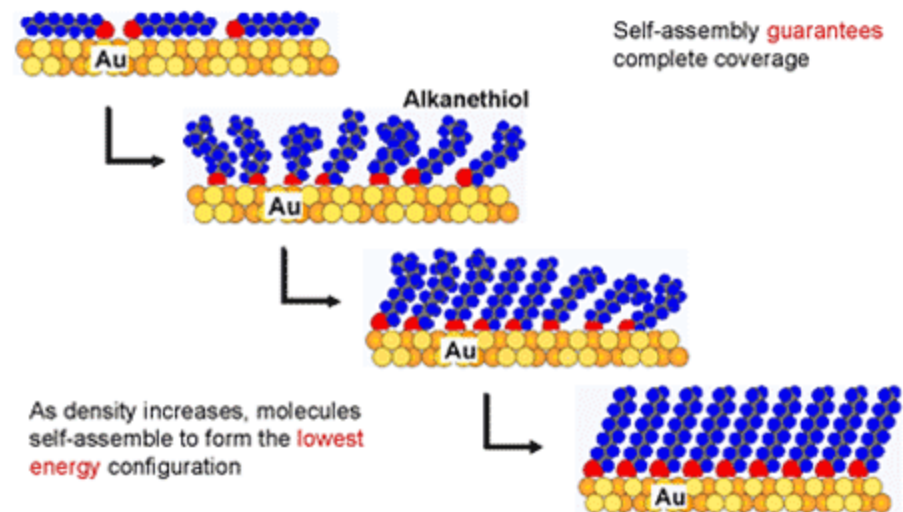


Nanotechnology may also be useful for developing ways to eradicate cancer cells without harming healthy, neighboring cells. Scientists hope to use nanotechnology to create therapeutic agents that target specific cells and deliver their toxin in a controlled, time-released manner.

3. How to research nanomaterial?

Preparation

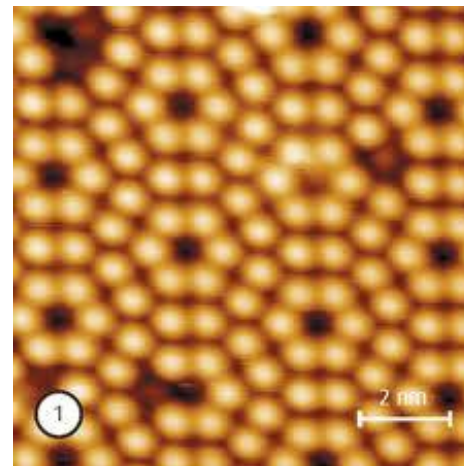
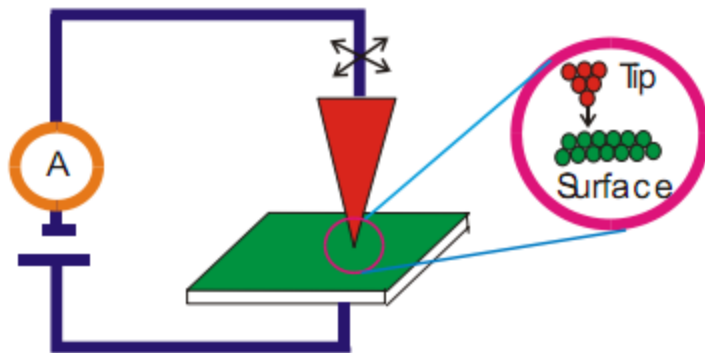
- Up to down
(Physical method)
- Down to up
(Chemical method)



Characterization

1. Scanning Tunneling Microscope (STM)

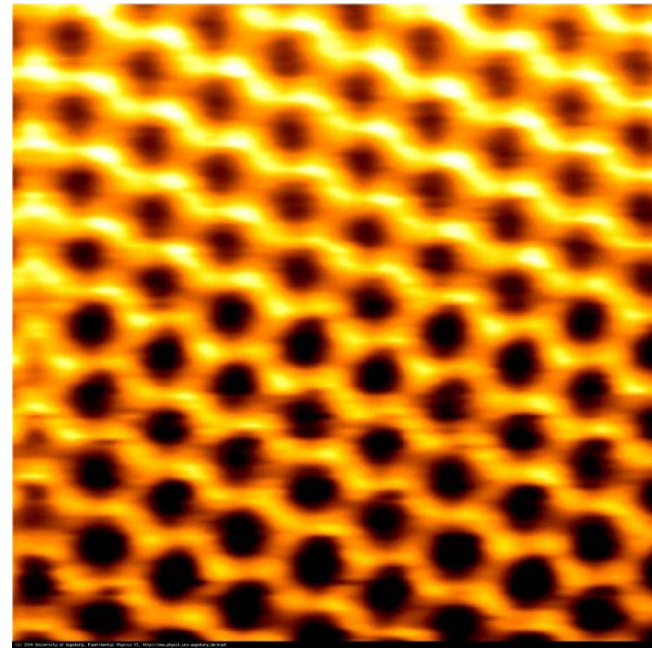
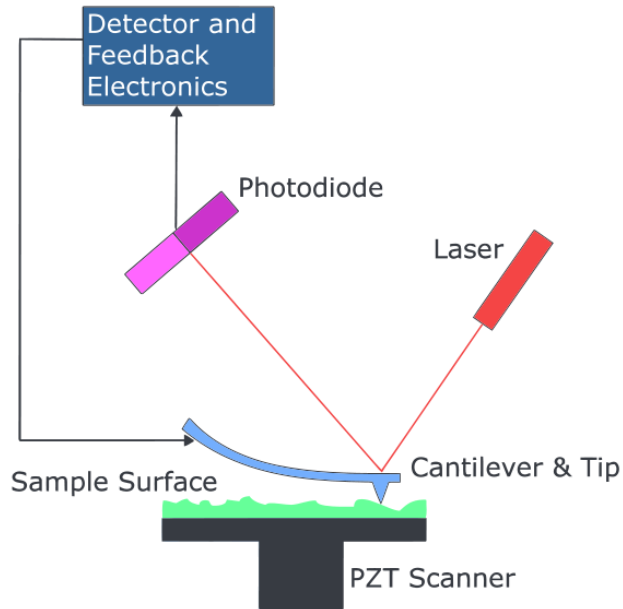
Works by sensing the tunneling current between the sharp tip and the conducting surface when the tip is brought close to the surface.



silicon

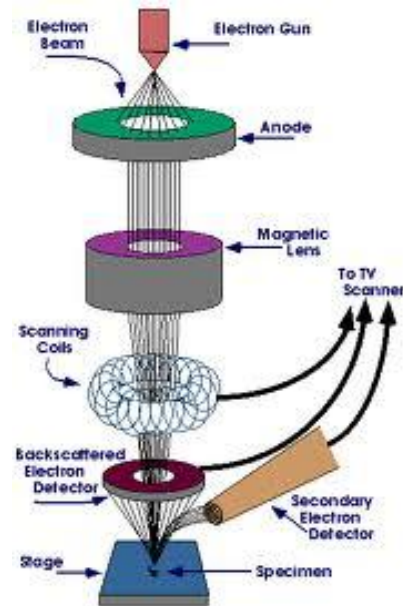
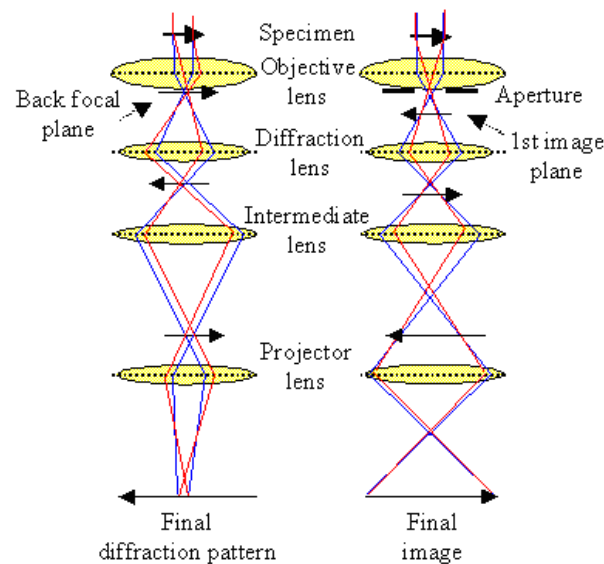
■ 2. Atomic Force Microscope

Measure the Van der Waals Force



tungsten

- 3. Transmission Electron Microscope
- Scanning Electron Microscope



references

- Applied nanotechnology. Jeremy Ramsden
- <http://en.wikipedia.org/wiki/Nanomaterials>
- http://en.wikipedia.org/wiki/Atomic_force_microscopy
- <http://en.wikipedia.org/wiki/Nanoelectronics>

Thank you!
