Electron microscope

In principle, an **electron microscope** is an (electron) analogue of an optical (photon) mikroscope. Optical lenses are replaced by electromagnetic lenses, and instead of photons, electrons are used to examine the object. Resolution and maximum usable magnification of optical microscope are limited by the wavelength range of visible light. It is true that the smallest distance between two objects that can still be recognized under a microscope is half the wavelength of the used light radiation. The physical limit of the resolving power of an optical microscope is thus less than 200 nm, and the maximum useful magnification of a microscope with high-quality optics and an immersion objective does not exceed 1500×. The wavelengths of accelerated electrons are many orders of magnitude smaller than the wavelengths of visible light photons. Therefore, the electron microscope has a much higher resolution and can thus achieve a much higher magnification (up to 1,000,000×).

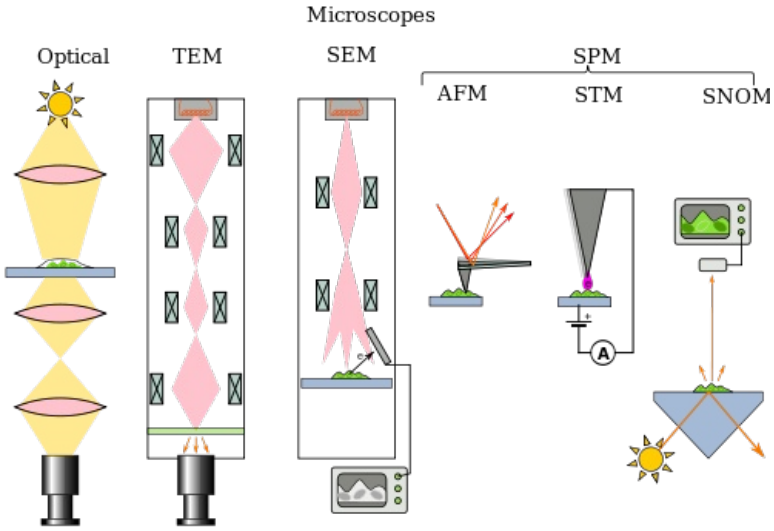
🔎 *For more information see Limit of resolution of optical microscope.*

The wavelength of the electron is only 0.0123 nm at an accelerating voltage of 10 kV.

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meU}}$$

(kinetic energy: $mv^2/2 = eU$)
$p = m \cdot v$ = momentum, h = Planck's constant, m = electron mass, e = electron charge, U = accelerating voltage

Appropriately shaped electromagnetic fields perform the function **of lenses** in an electron microscope. The observed object is placed in a vacuum and we "illuminate" it with a beam of electrons, which **scatters through the passage and hits the screen**.



Overview of types of microscopes

Types of microscopes

- **TEM** transmission electron microscope – stationary pack of electrons, detection of electrons passing through the sample (TE) on a fluorescent screen or detector.
- **SEM** scanning electron microscope – moving pack, imaging the sample surface using reflected secondary electrons.
- **SPM** scanning probe microscopy is a complex of methods designed to detect the surface structure on atom level resolution.
  - **AFM** atomic force microscopy is based on mapping the distribution of atomic forces on the sample surface. These forces are mapped by closing the apex closer to the surface, creating an attractive or repulsive force that causes the beam on which the apex is attached to bend. This bending is scanned by a laser sensor. The advantage of the AFM method is the possibility to study both non-conductive and conductive samples.
  - **STM** scanning tunnel microscopy is one of the SPM methods. Its principle is based on quantum physics. A current flows between the apex of the electrode and the examined sample due to the tunneling effect, even if the apex does not directly touch the sample. When moving above the sample, the apex distance is changed so that the tunnel current remains the same. As one of the few methods, it is able to provide up to atomic resolution, whilst being quite simple. Compared to other methods (transmission electron microscopy, autoemission ion microscopy), it does not require demanding sample preparation. On the other hand, it only provides information about the surface.
  - **SNOM** scanning near-filed optical microscope [1]

Links

Related articles

- Optical microscopy
- Confocal microscopy
- Microscopic techniques
- Contrast of optical microscope
- Transmission Electron Microscopy
- Scanning Electron Microscopy
- Limit of resolution of optical microscope

External links

- Pavel Janda: Mikroskopické a analytické techniky – mikroskopie rastrovací sondou (http://www.njh.cz/seminare/457865/1270587)
- Mikroskop atomárních sil použit jako atomární tužka umožňující psaní jednotlivými atomy (http://strediskovedy.cz/attachment/atomarni-tuzka.doc)
- Nové možnosti zobrazování jednotlivých atomů pomocí rastrovacích mikroskopů (http://www.avcr.cz/cs/pro-media/UserFiles/file/aktuality_pdf/100104_TZ_Novemoznostirastrovacichmikroskopu.pdf)

References

1. Jan Valenta, Spektroskopie jednotlivých molekul v blízkém optickém poli, Vesmír 74, 236, 1995/4 available online (http://www.vesmir.cz/clanek/spektroskopie-jednotlivych-molekul-v-blizkem-optickem-poli-(2))

Used literature

- JELÍNEK, Pavel – HAPALA, Prokop – CHÁB, Vladimír. Rastrovací a tunelová mikroskopie : Jitro a poledne kouzelníků. *Vesmír* [online]. 2010, y. 89, vol. 5, p. 290-294, Available from <http://casopis.vesmir.cz/clanek/rastrovaci-tunelova-mikroskopie>. ISSN 1214-4029.