TRANSMISSION ELECTRON MICROSCOPY (TEM)

Principle

- In this technique, a beam of high-energy electrons (typically 100 – 400 keV) is collimated by magnetic lenses and allowed to pass through a specimen under high vacuum.
- The transmitted beam and a number of diffracted beams can form a resultant diffraction pattern, which is imaged on a fluorescent screen kept below the specimen.
- The diffraction pattern gives the information regarding lattice spacing and symmetry of the structure under consideration.

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Principle

- Alternatively, either the transmitted beam or the diffracted beams can be made to form a magnified image of the sample on the viewing screen as bright-and dark field imaging modes respectively. This gives information about the size and shape of the micro-structural constituents of the material.
- High - resolution image contains information about the atomic structure of the material. This can be obtained by recombining the transmitted beam and diffracted beams together

Instrumentation

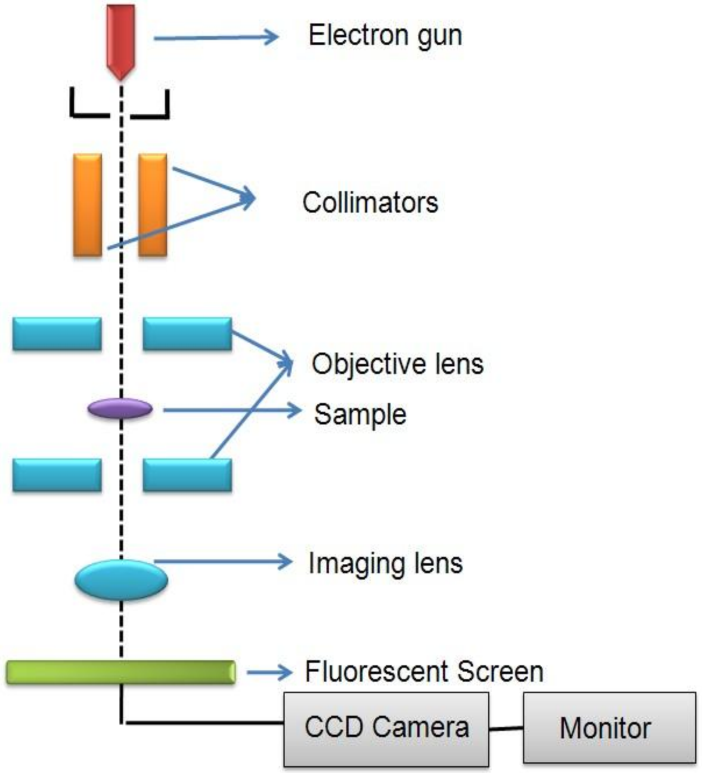
- It comprises of a tungsten filament or LaB_6 or a field emission gun as source of electron beam, objective lens, imaging lens, CCD camera, monitor, etc.
- The ray of electrons is produced by a pin-shaped cathode heated up by current. The electrons are vacuumed up by a high voltage at the anode.

Instrumentation

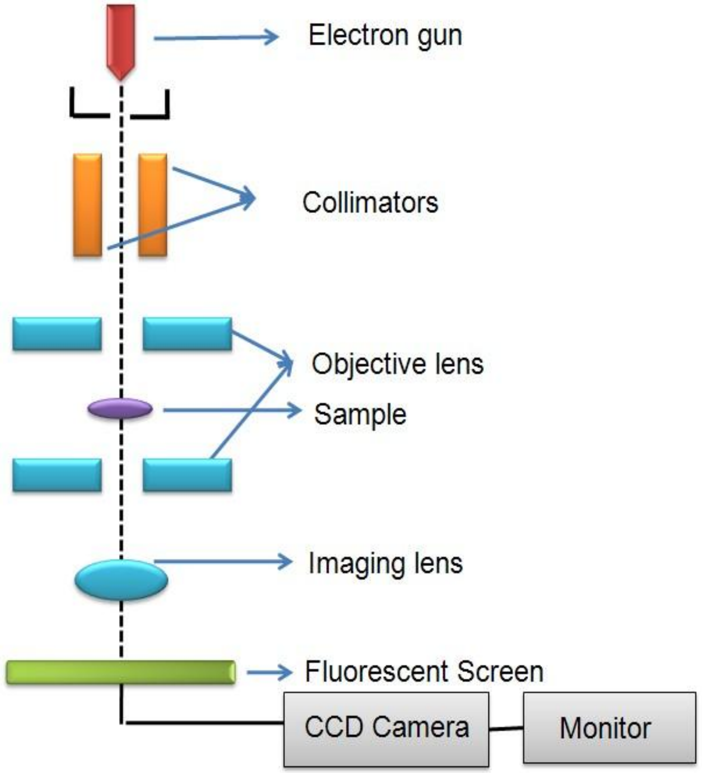
- The acceleration voltage is between 50 and 150 kV. The higher it is, the shorter are the electron waves and the higher is the power of resolution, but this factor is hardly ever limiting.
- The power of resolution of electron microscopy is usually restrained by the quality of the lens-systems and especially by the technique with which the preparation has been made. Modern gadgets have powers of resolution that range from 0.2 - 0.3 nm.

Instrumentation

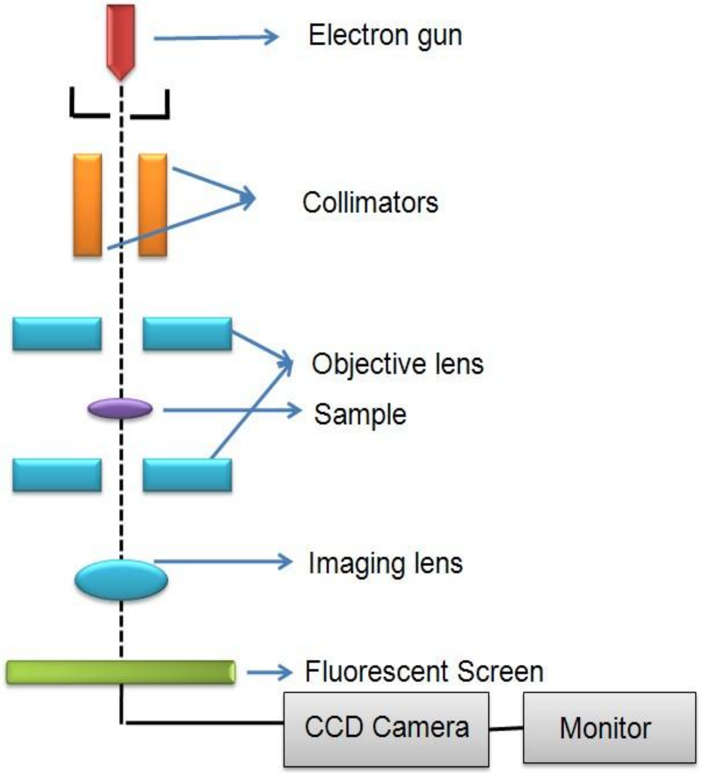
- The accelerated ray of electrons passes a drill-hole at the bottom of the anode. Its following way is analogous to that of a ray of light in a light microscope. The lens-systems consist of electronic coils generating an electromagnetic field.



- The ray is first focused by a condenser and then passes through the object, where it is partially deflected. The degree of deflection depends on the electron density of the object.
- The greater the mass of the atoms, the greater is the degree of deflection.



- Biological objects have only weak contrasts since they consist mainly of atoms with low atomic numbers (C, H, N, O). Consequently, it is necessary to treat the preparations with special contrast enhancing chemicals (heavy metals) to get at least some contrast.
- Additionally, they are not thicker than 100 nm, because the temperature rises due to electron absorption. It is generally impossible to examine living things.



- After passing through the object, the scattered electrons are collected by an objective. Thereby an image is formed, that is subsequently enlarged by an additional lens - system (called projective with electron microscopes).

- The formed image is made visible on a fluorescent screen or it is documented on photographic material.
- Photos taken with electron microscopes are always black and white.
- The degree of darkness corresponds to the electron density (differences in atom masses) of the candled preparation.

Applications

- Transmission electron microscopy is used to study the local structures, morphology, dispersion of multi - component polymers, cross sections and crystallization of metallic alloys semiconductors, microstructure of composite materials, etc.

Applications

- The instrument can be extended to include other detectors like Energy Dispersive Spectrometer (EDS) or Energy Loss Spectrometer (ELS) to study about the local chemistry of the material similar to SEM technique

Thank You