**TOPIC :** Transmission Electron Microscope
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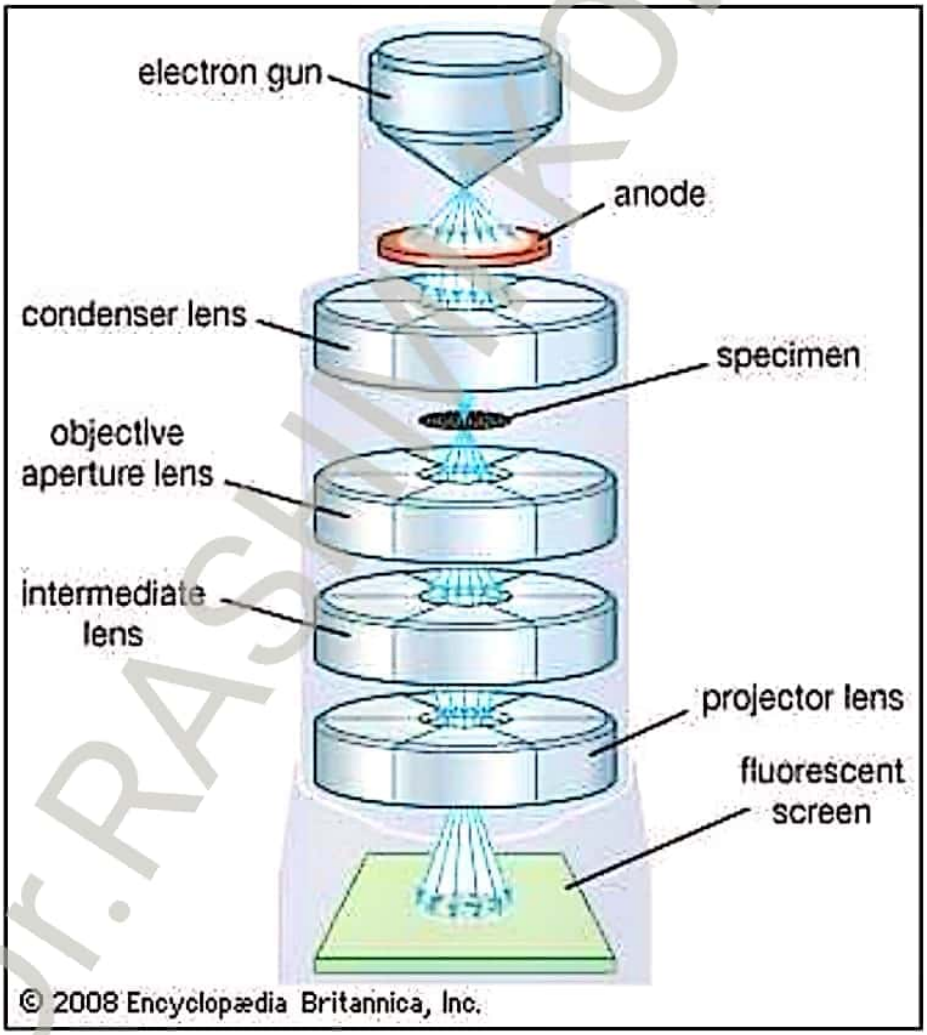
# Transmission Electron Microscope

**Transmission electron microscopy** (**TEM**) is a microscopy technique in which a beam of electrons is transmitted through a specimen to form an image. The specimen is most often an ultrathin section less than 100 nm thick or a suspension on a grid.



## Principle :

TEM works like a slide projector. A projector shines a beam of light which transmits through the slide. The patterns painted on the slide only allow certain parts of the light beam to pass through. Thus the transmitted beam replicates the patterns on the slide, forming an enlarged image of the slide when falling on the screen.

TEMs work the same way except that they shine a beam of electrons (like the light in a slide projector) through the specimen (like the slide). However, in TEM, the transmission of electron beam is highly dependent on the properties of material being examined. Such properties include density, composition, etc. For example, porous material will allow more electrons to pass through while dense material will allow less. As a result, a specimen with a non-uniform density can be examined by this technique. Whatever part is transmitted is projected onto a phosphor screen for the user to see.

## Working :

When an electron beam passes through a thin-sectional specimen of a material, electrons are scattered. A sophisticated system of electromagnetic lenses focuses the scattered electrons into an image / a diffraction pattern, or a nano - analytical spectrum, depending on the mode of operation. The beam of electrons from the electron gun is focused into a small, thin, coherent beam by the use of the condenser lens. This beam is restricted by the condenser aperture, which excludes high angle electrons. The beam then strikes the specimen and parts of it are transmitted depending upon the thickness and electron transparency of the specimen. This transmitted portion is focused by the objective lens into an image on phosphor screen or charge coupled device (CCD) camera. The image then passed down the column through the intermediate and projector lenses, is enlarged all the way.

## Parts :

A TEM contains four parts:

- electron source,
- electromagnetic lens system,
- sample holder, and
- imaging system.

**Electron source :** The electron source consists of a cathode and an anode. The cathode is a tungsten filament which emits electrons when being heated. A negative cap confines the electrons into a loosely focused beam (Fig. 5). The beam is then accelerated towards the specimen by the positive anode. Electrons at the rim of the beam will fall onto the anode while the others at the center will pass through the small hole of the anode. The electron source works like a cathode ray tube.

**Electromagnetic lens system :** After leaving the electron source, the electron beam is tightly focused using electromagnetic lens and metal apertures. The system only allows electrons within a small energy range to pass through, so the electrons in the electron beam will have a well-defined energy.

1. Magnetic Lens: Circular electro-magnets capable of generating a precise circular magnetic field. The field acts like an optical lens to focus the electrons.
2. Aperture: A thin disk with a small (2-100 micrometers) circular through-hole. It is used to restrict the electron beam and filter out unwanted electrons before hitting the specimen.

**Sample holder :** The sample holder is a platform equipped with a mechanical arm for holding the specimen and controlling its position.

**Imaging system :** The imaging system consists of another electromagnetic lens system and a screen. The electromagnetic lens system contains two lens systems, one for refocusing the electrons after they pass through the specimen, and the other for enlarging the image and projecting it onto the screen. The screen has a phosphorescent plate which glows when being hit by electrons. Image forms in a way similar to photography.

## Applications :

- A Transmission Electron Microscope is ideal for a number of different fields such as life sciences, nanotechnology, medical, biological and material research, forensic analysis, gemology and metallurgy as well as industry and education.
- TEMs provide topographical, morphological, compositional and crystalline information.
- The images allow researchers to view samples on a molecular level, making it possible to analyze structure and texture.
- This information is useful in the study of crystals and metals, but also has industrial applications.
- TEMs can be used in semiconductor analysis and production and the manufacturing of computer and silicon chips.
- Technology companies use TEMs to identify flaws, fractures and damages to micro-sized objects; this data can help fix problems and/or help to make a more durable, efficient product.
- Colleges and universities can utilize TEMs for research and studies.
- Although electron microscopes require specialized training, students can assist professors and learn TEM techniques.
- Students will have the opportunity to observe a nano-sized world in incredible depth and detail.

## Strengths :

A Transmission Electron Microscope is an impressive instrument with a number of advantages such as:

- TEMs offer the most powerful magnification, potentially over one million times or more
- TEMs have a wide-range of applications and can be utilized in a variety of different scientific, educational and industrial fields
- TEMs provide information on element and compound structure
- Images are high-quality and detailed

- TEMs are able to yield information of surface features, shape, size and structure
- They are easy to operate with proper training

## Limitations :

Some cons of electron microscopes include:

- TEMs are large and very expensive
- Laborious sample preparation
- Potential artifacts from sample preparation
- Operation and analysis requires special training
- Samples are limited to those that are electron transparent, able to tolerate the vacuum chamber and small enough to fit in the chamber
- TEMs require special housing and maintenance
- Images are black and white
- Electron microscopes are sensitive to vibration and electromagnetic fields and must be housed in an area that isolates them from possible exposure.
- Requires constant upkeep including maintaining voltage, currents to the electromagnetic coils and cooling water.



**FIG :** Transmission Electron Microscope

Reference :


- microscopemaster.com
- en.wikipedia.org
- google.com


Thankyou