LED (Light Emitting Diode)

An **LED (Light Emitting Diode)** is a **semiconductor light source** that emits light when current flows through it. Unlike incandescent or fluorescent bulbs, LEDs do not rely on heating a filament or gas to produce light. Instead, they work based on the principle of **electroluminescence**, where **electrons** recombine with **electron holes** within a material, releasing energy in the form of photons (light). LEDs are widely used for various applications due to their **energy efficiency**, **long lifespan**, and **compact size**.

How an LED Works:

1. **Semiconductor Materials**:
    - LEDs are made from **semiconductor materials**, most commonly **gallium** (Ga), **arsenic** (As), **phosphide** (P), and others. The material determines the color (wavelength) of the emitted light.
2. **Forward Bias**:
    - When a voltage is applied across the LED in the forward direction (positive to the anode and negative to the cathode), current flows through the semiconductor. This causes **electrons** to recombine with **holes** (vacancies of electrons), and the excess energy is emitted as **photons** (light).
3. **Electroluminescence**:
    - The light emitted by the LED comes from the process of **electroluminescence**, which occurs as electrons from the negative side (cathode) recombine with holes on the positive side (anode) inside the semiconductor.
4. **Color of Light**:
    - The **color** of the light emitted by an LED depends on the energy band gap of the semiconductor material. For example:
        - **Red LEDs**: Use materials like **Gallium Arsenide** (GaAs) and **Gallium Phosphide** (GaP).
        - **Blue LEDs**: Typically made from **Gallium Nitride** (GaN).

- **Green LEDs**: Made from **Gallium Phosphide** (GaP) or **Indium Gallium Nitride** (InGaN).

- **White LEDs**: Often created by coating a blue LED with a **phosphor** material or by using a combination of red, green, and blue LEDs.