



University of Babylon
College of Material Engineering
Department of Metallurgical Engineering

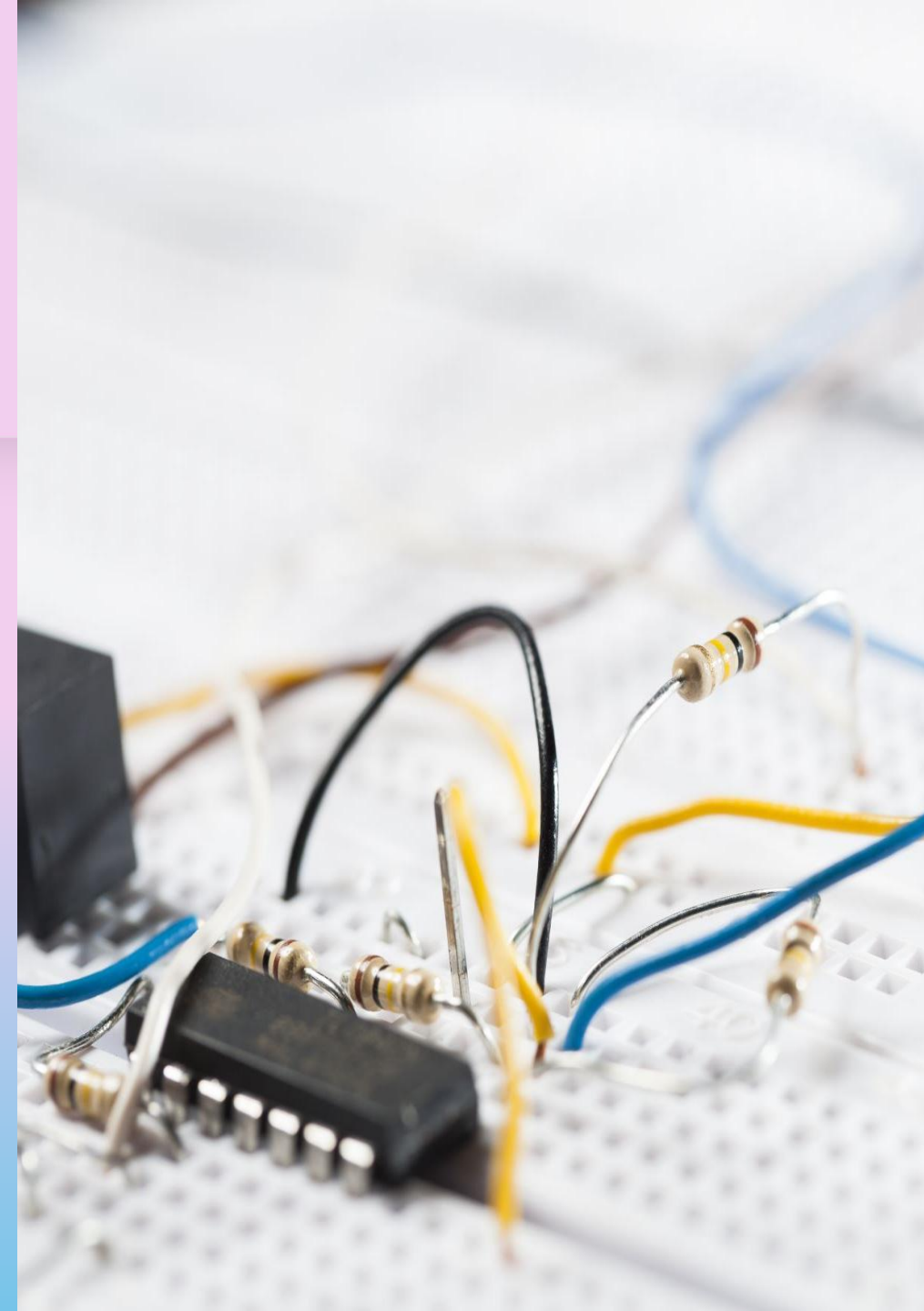
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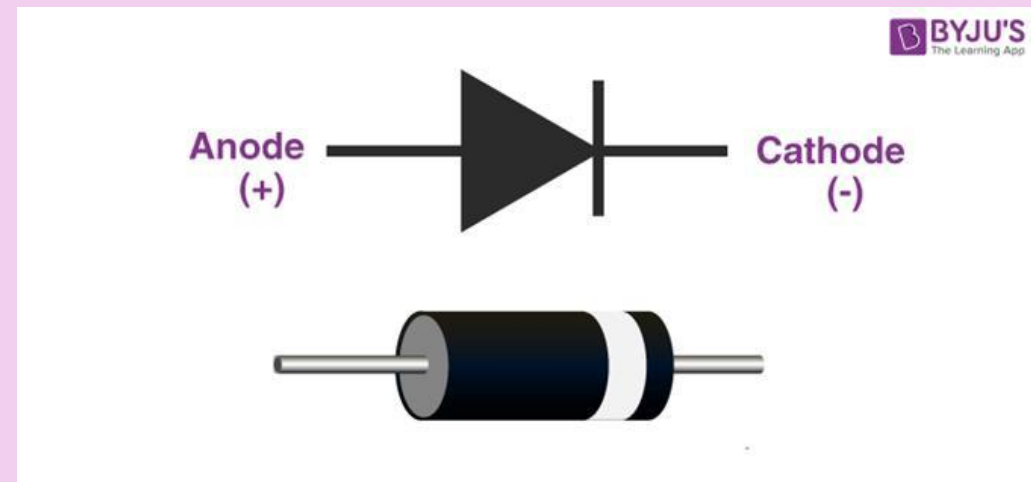
Lecturer: Dr. Qabas Khalid Naji

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Diodes



- A diode is an electronic component and a semiconductor device that basically acts as a one-way switch for electrical current in a circuit. Diodes are used to protect circuits by limiting the voltage and to also transform AC into DC. Semiconductors like silicon and germanium are used to make the most of the diodes. Even though they transmit current in a single direction, the way with which they transmit differs. There are different kinds of diodes and each type has its own applications.
- A standard diode symbol is represented as above. In the above diagram, we can see that there are two terminals that are known as anode and cathode. The arrowhead is the anode that represents the direction of the conventional current flow in the forward biased condition. The other end is the cathode.

How Does a Diode Work?

We already explained that a diode controls the flow of electrical current using two types of semiconductor materials, but how exactly does it work?

Forward bias: When the positive voltage is applied to the P-side and negative voltage to the N-side, the P-N junction reduces its internal resistance, which makes the current flow.

Reverse bias: When the polarity is reversed in the reverse bias, the positive voltage needs to be applied to the N-side and negative to the P-side. This creates two end results as it increases the resistance of the junction, while also blocking current flow.

Breakdown voltage: While diodes are designed to block reverse currents, exceeding a specific threshold voltage can cause the diode to conduct in reverse, a feature intentionally used in Zener diodes for voltage regulation.

Diode Construction

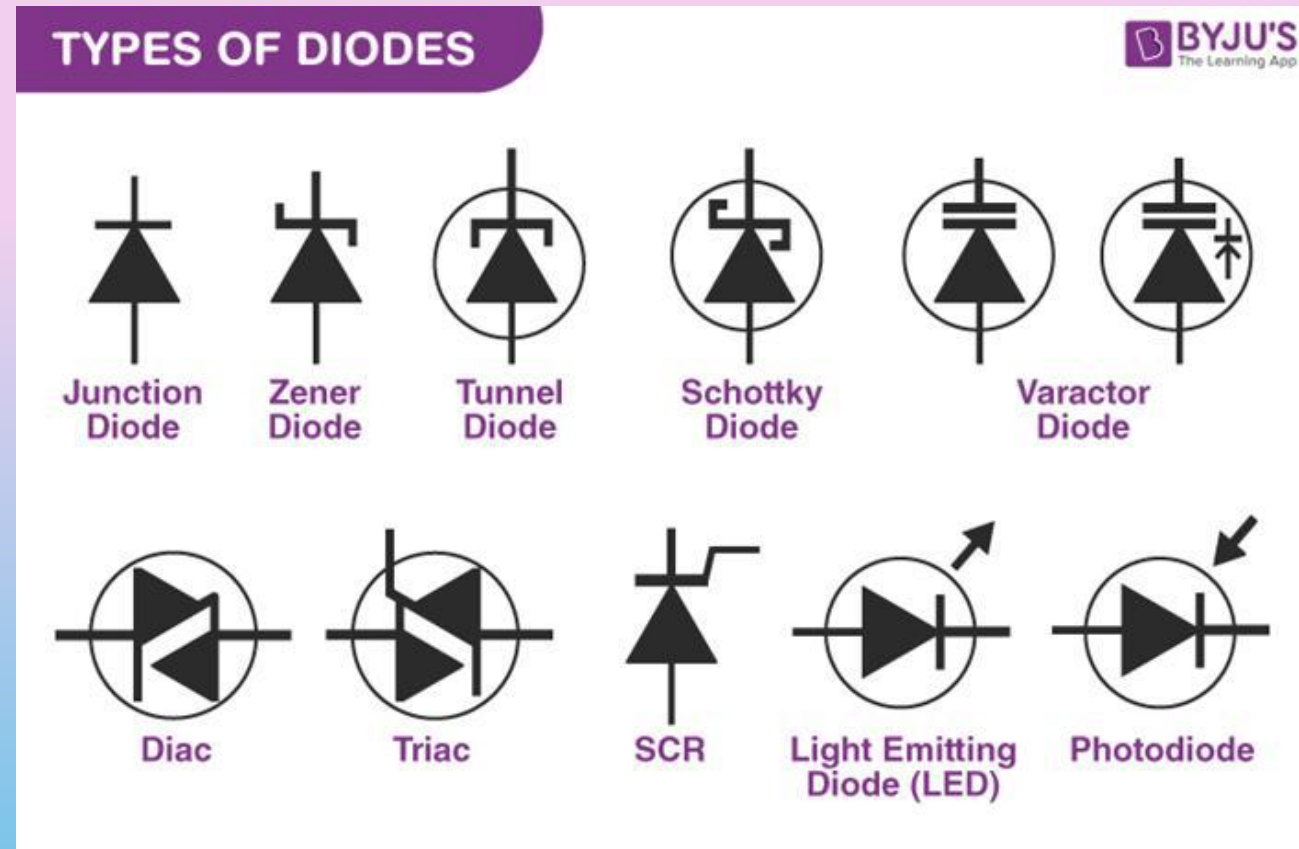
Diodes can be made of either of the two semiconductor materials, silicon and germanium. When the anode voltage is more positive than the cathode voltage, the diode is said to be forward-biased, and it conducts readily with a relatively low-voltage drop. Likewise, when the cathode voltage is more positive than the anode, the diode is said to be reverse-biased. The arrow in the diode symbol represents the direction of conventional current flow when the diode conducts.

Types of Diodes

Diodes come in various types, and each type has a specific purpose in the electronic circuit.

The most common types of diodes include:

1. Light Emitting Diode
2. Laser diode
3. Avalanche diode
4. Zener diode
5. Schottky diode
6. Photodiode
7. PN junction diode



1. Rectifier Diodes

Typically created for alternating current (AC) into direct current (DC), rectifier diodes facilitate an essential process for powering electronic devices. They're mostly used in power supplies for converting household AC power into the DC power required by electronics. Take a laptop charger, for example. Inside the charger, rectifier diodes convert wall socket electricity into stable DC power to charge your battery safely.

2. Zener Diodes

These diodes are created to regulate voltage and protect circuits using reverse bias mode. The reason why they are ideal for voltage regulation is because they allow current to flow in reverse once a specific voltage is reached. For example, mobile phones have Zener diodes because they provide microprocessors in the phone with stable voltage at all times.

3. Light-Emitting Diodes (LEDs)

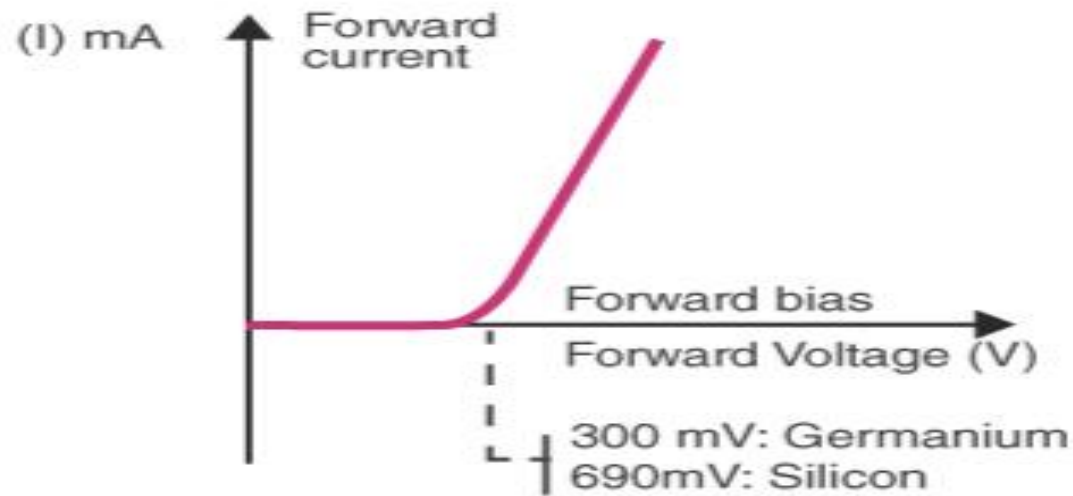
LEDs are diodes that emit light when an electric current passes through them, making them energy-efficient and versatile light sources. LEDs use electroluminescence to convert electrical energy directly into light, with minimum heat generation. You've probably seen LED bulbs that can either change colors based on a preset pattern or sync dynamically to a pattern of a song, making any room feel like a party.

4. Schottky Diodes

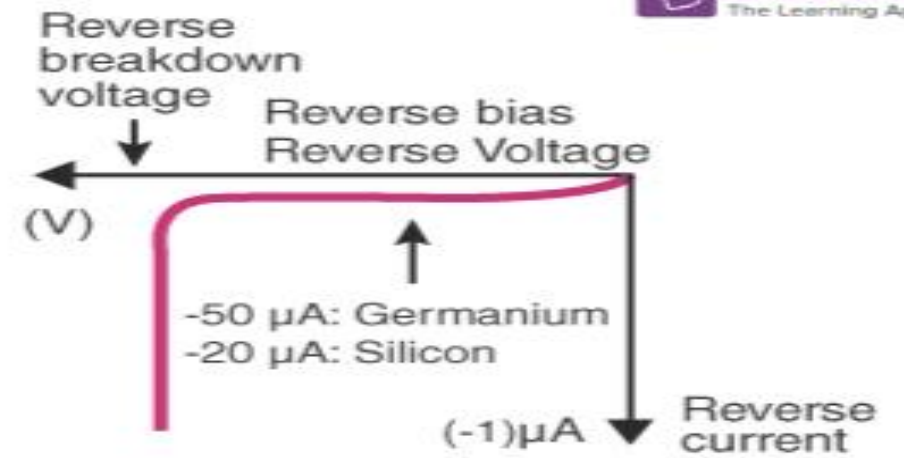
Known for their low forward voltage drop and fast switching capabilities, Schottky diodes are the best choice for high speed and high-efficiency applications. These diodes have a metal-semiconductor junction instead of a P-N junction, allowing them to operate at higher speeds with minimal energy loss. For example, Schottky diodes in computer processors enable quick data transfer by improving the speed of logic circuits.

Characteristics of Diode

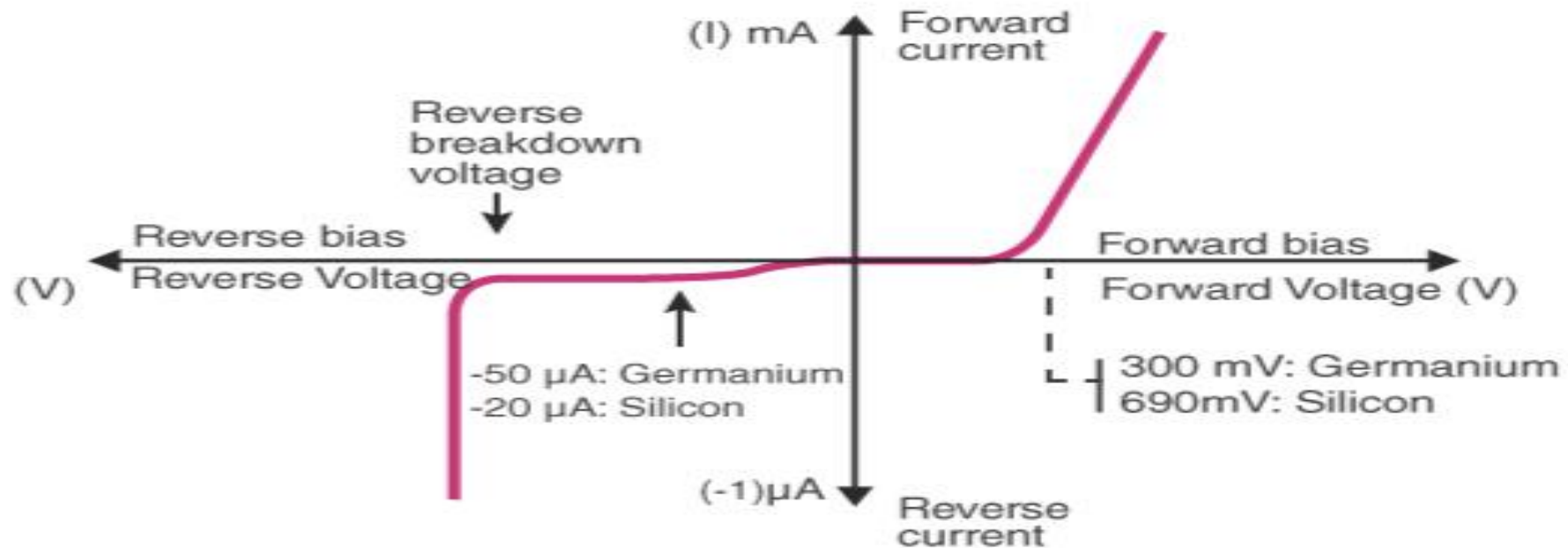
- The following are the characteristics of the diode:
- Forward-biased diode
- Reverse-biased diode
- Zero biased diode



Forward-biased diode



Reverse-biased diode



VI characteristics of Diode

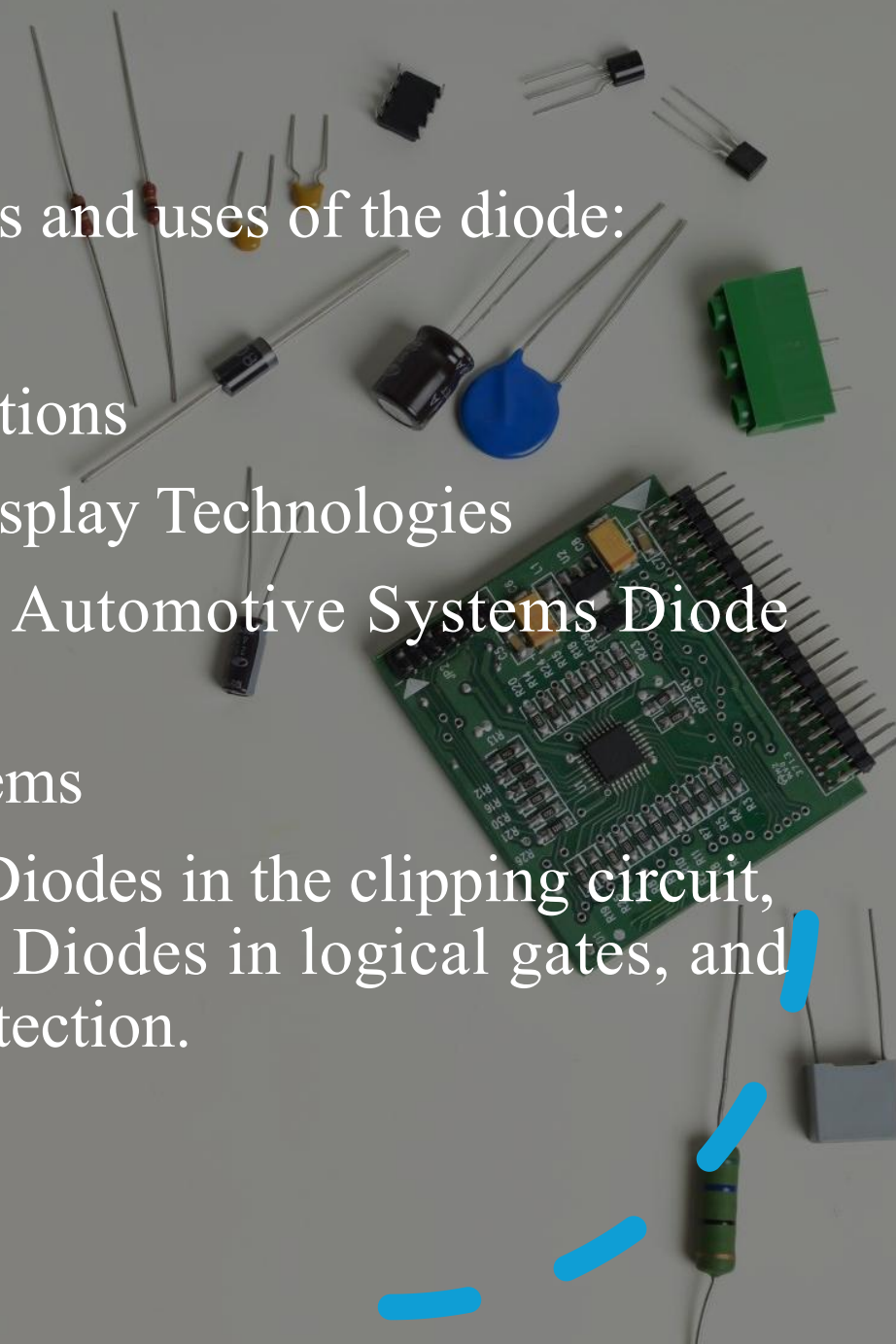
1. Forward-biased Diode : There is a small drop of voltage across the diode when the diode is forward-biased and the current is conducting. For silicon diodes, the forward voltage is 690mV and for germanium, 300mV is the forward voltage. The potential energy across the p-type material is positive and across the n-type material, the potential energy is negative.
2. Reverse-biased Diode : A diode is said to be reverse-biased when the battery's voltage is dropped completely. For silicon diodes, the reverse current is $-20\mu\text{A}$ and for germanium, $-50\mu\text{A}$ is the reverse current. The potential energy across the p-type material is negative and across the n-type material, the potential energy is positive.
3. Zero-biased Diode: When the diode is zero-biased, the voltage potential across the diode is zero.

Diode Applications

Following are the applications and uses of the diode:

1. Diodes in Power Supplies
2. Signal Processing Applications
3. Diodes in Lighting and Display Technologies
4. Telecommunications and Automotive Systems Diode Usage.
5. Diodes in automotive systems

Diodes also used a rectifier, Diodes in the clipping circuit, Diodes in clamping circuits, Diodes in logical gates, and Diodes in reverse current protection.



The versatile function of diodes is rapidly being implemented in many new applications.

Applications of diodes in electronics include:

1. Diodes in Power Supplies

Diodes are required for converting and stabilizing electrical power. Rectifier diodes for example, are used in power supplies to convert AC to DC, ensuring electronic devices operate reliably.

Example: Every time you charge your smartphone or your laptop, diodes in the charger convert household AC electricity into DC power.

2. Signal Processing Applications

Diodes are used for controlling, filtering, and amplifying electrical signals in signal processing applications. Their ability to regulate current flow and rectify signals makes them a core electronic component in audio and communication systems.

Example: In radios, diodes demodulate AM or FM signals, transforming them into audible sound. Comparably, in audio systems, diodes prevent interference and stabilize signals, providing clear sound quality.

3. Diodes in Lighting and Display Technologies

LEDs have revolutionized lighting and displays, offering energy-efficient and durable solutions for various applications. These light-emitting diodes convert electrical energy into light with minimal heat generation.

Example: LED TVs, smartphones, and smartwatches — they all rely on LEDs for vibrant, high-resolution displays that we experience on a daily basis.

4. Telecommunications and Automotive Systems Diode Usage

In telecommunications and automotive industries, diodes are mostly used to boost performance, provide reliability, and manage power effectively.

Diodes in telecommunications: The photodiodes in fiber-optic networks are mostly used in telecommunications because they are able to detect light signals, providing high-speed internet and data transmission. The most common type of diode in this case is the Schottky diode, because it supports quick switching for signal amplification, improving the process of communication systems.

5. Diodes in automotive systems:

Zener diodes act as guardians of automotive control systems, as they stabilize voltage to protect delicate electronics from power spikes. They're also used in sleek designs of certain cars, where LEDs illuminate dashboards and taillights while consuming less power.

The Junction-Type Bipolar (Transistor)

- When explaining what a diode is, it's also important to understand that a diode has a fundamental component called P-N junction. This is where two types of semiconductor materials, called P-type (positive) and N-type (negative), meet.
- Combining two or more p-n junction arrangements (p-n-p, n-p-n, etc.) into one device resulted in the development of the transistor. The transistor is a device capable of amplifying a signal or switching a current on and off billions of times per second. Its development dawned a new age in electronics.
- Since its inception in 1948 by W. Shockley, J. Bardeen, and W. Brattain of Bell Laboratories, the transistor has evolved into many forms. The original device (Fig.4) used point contacts to penetrate the body of a germanium semiconductor. Subsequent transistors were of the junction (bipolar) type with germanium as the semiconductor. The semiconductor material was later replaced with silicon.

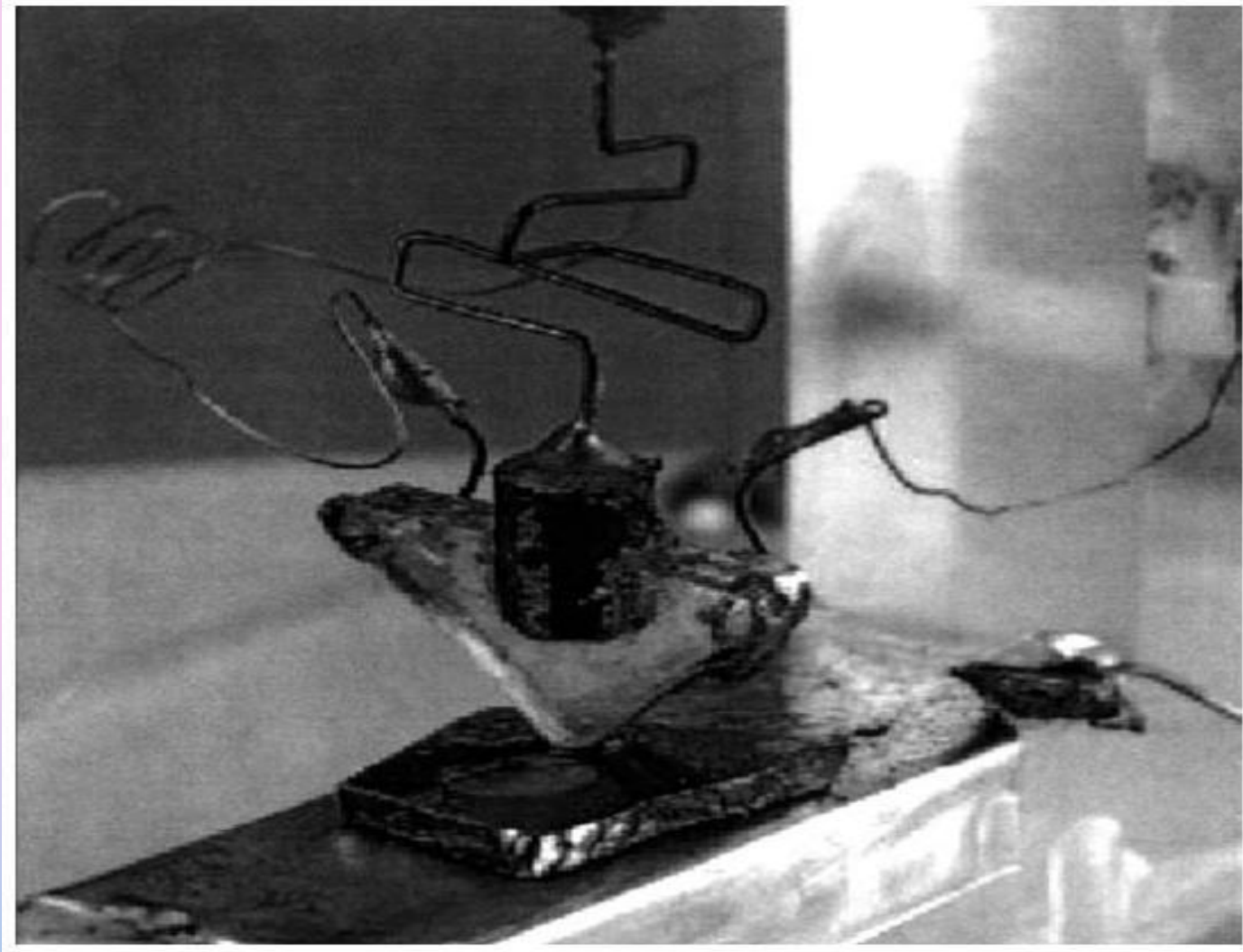
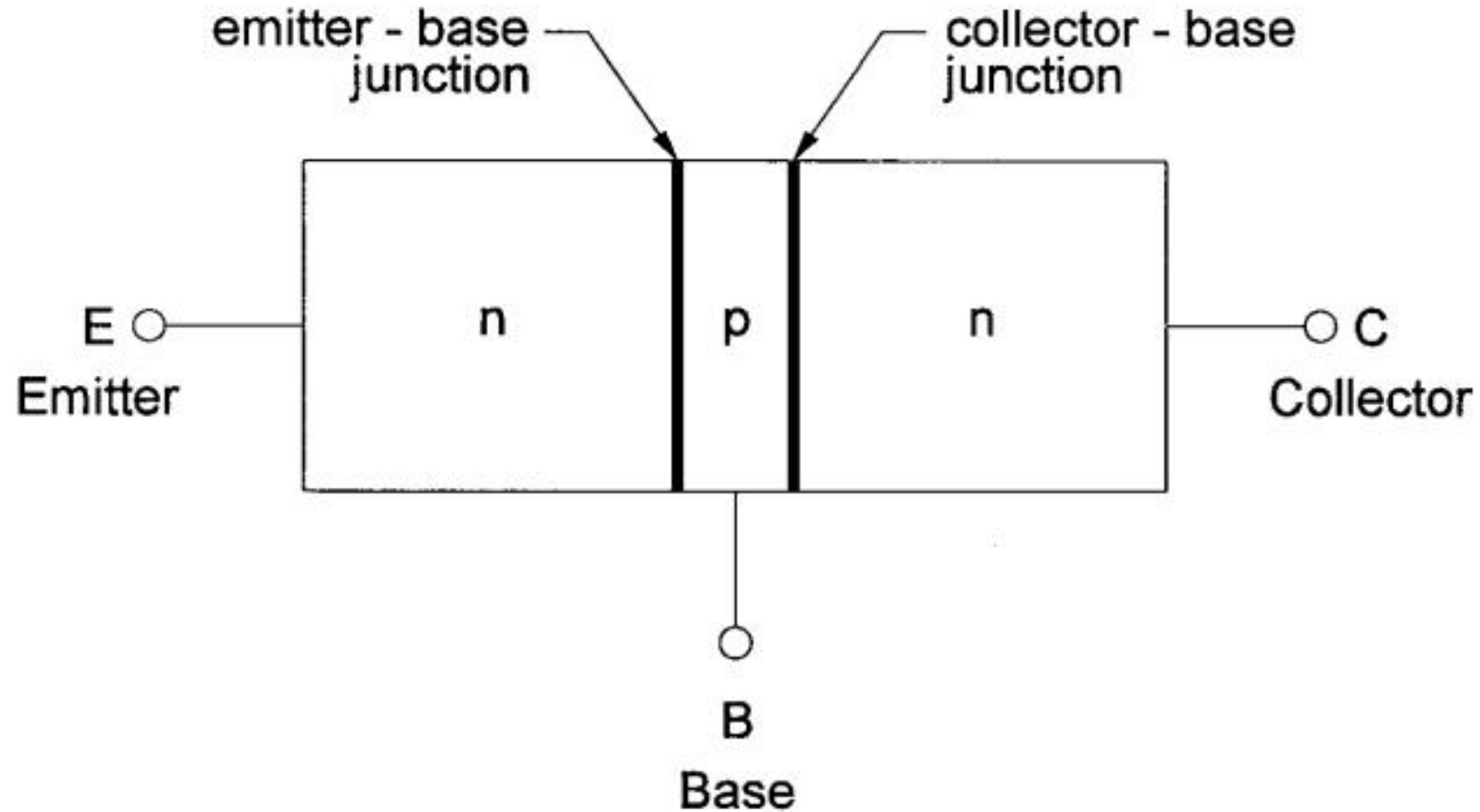


Fig 4: The original point-contact transistor.

- To illustrate how a bipolar transistor works, an n-p-n semiconductor configuration (Fig.5) is used as an example. In this structure, a very thin, lightly doped p-region, called the base (B), is sandwiched between two thicker outer n-regions, called the emitter (E) and collector (C). The emitter generates electrons, the collector absorbs the electrons, and an input signal applied at the base controls the electron flow from emitter to collector.
- The input power is equal to the a.c. emitter current multiplied by the emitter base voltage, which is small. The output power is greater, being equal to the a.c. emitter current multiplied by the (larger) collector base voltage. The transistor is thus a power amplifier.

Fig 5: Typical n-p-n transistor.



A close-up, low-angle shot of a glowing green circuit board. The board is illuminated with a vibrant green light, creating a futuristic and high-tech atmosphere. The intricate patterns of the circuitry are visible, with various components and traces. The text "Thank you" is overlaid in a white, serif font, centered in the upper half of the image. The background is dark, making the glowing green elements stand out prominently.

Thank you