Semi Conductors


What is a
SEMICONDUCTOR?

Semiconductors

Semiconductors are substances with a solid chemical element or compound that can conduct electricity under some conditions but not in others, making them ideal for the control of electrical current.

Its conductance varies depending on the current or voltage applied.

Semiconductors sit between **conductors and insulators**, being neither good conductors, nor good insulators. Semiconductor materials also contain

?

4

electrons in their outer electron shell (valence shell).

Semiconductors

Most group 14 elements in the periodic table can be semiconductors. The arrangement of atoms in the semiconductor is very important, semiconductors must have a cubic crystal structure to function properly. Silicon or Germanium are the most common

Semiconductors

Materials

Semiconductors include, Arsenic, Boron, Carbon, Germanium, Silicon, Sulphur. Silicon is the best known of these, forming the basis of most integrated circuits (IC's).

Doping “P Type” Material

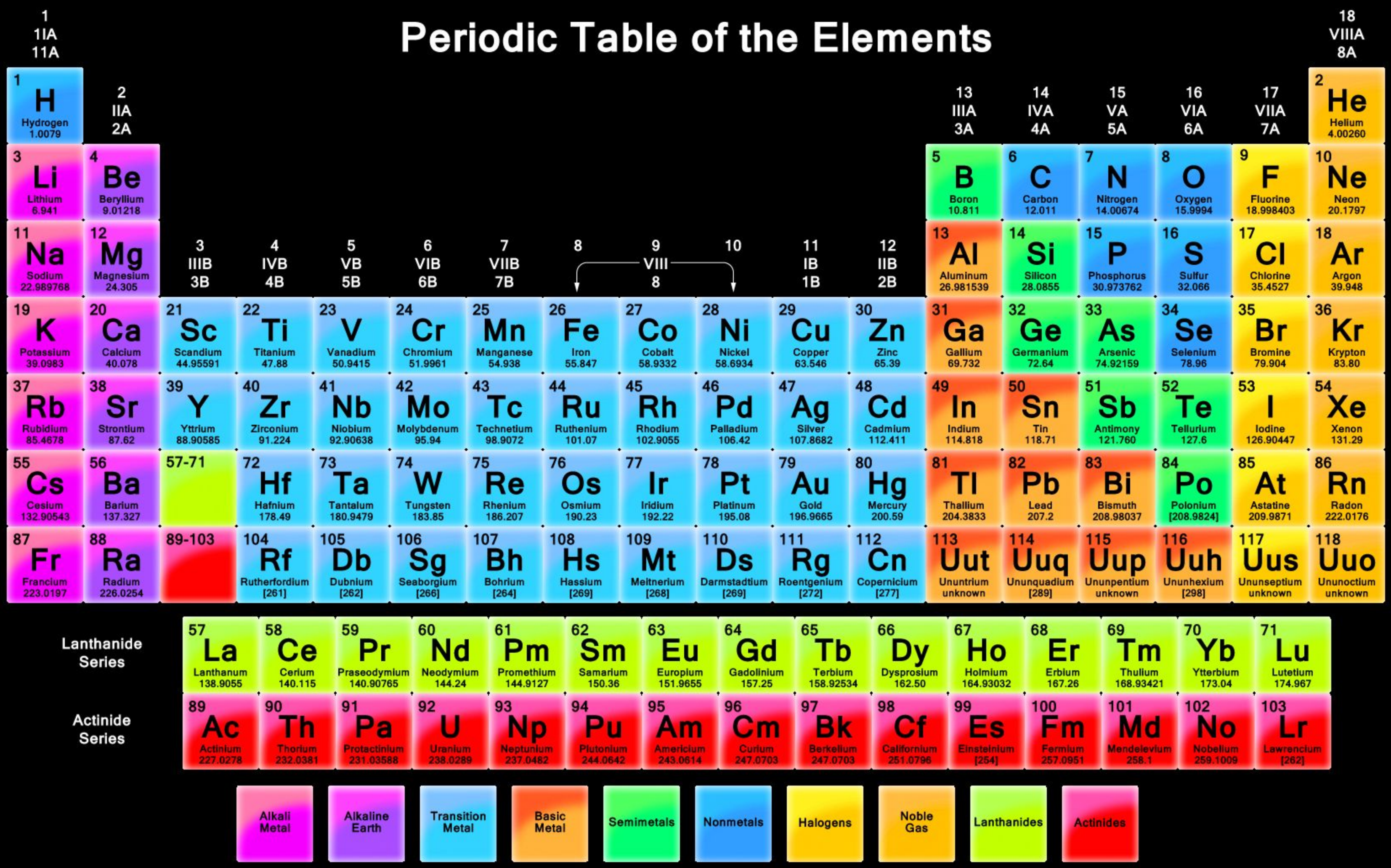
Two different types of semiconductor can be made by adding tiny amounts of impurities to the semiconductor material in a process known as doping.

One type of semiconductor is the P type which is made by adding a small amount of Boron.

Boron (B) is a group 13 element, that has 3 electrons in its outer shell, so when its added to the crystal structure it leaves a gap known as a ’**hole**’.

Because of this it is known as an accepter impurity because the hole can accept an electron.

Periodic Table of the Elements



Doping "N Type" Material

The other type is the N type semiconductor which is doped with Phosphorous (P) which is a group 15 element that has 5 electrons in its outer shell,

When added to the crystal structure it leaves a free electron, known as a donor impurity therefor has surplus electrons.

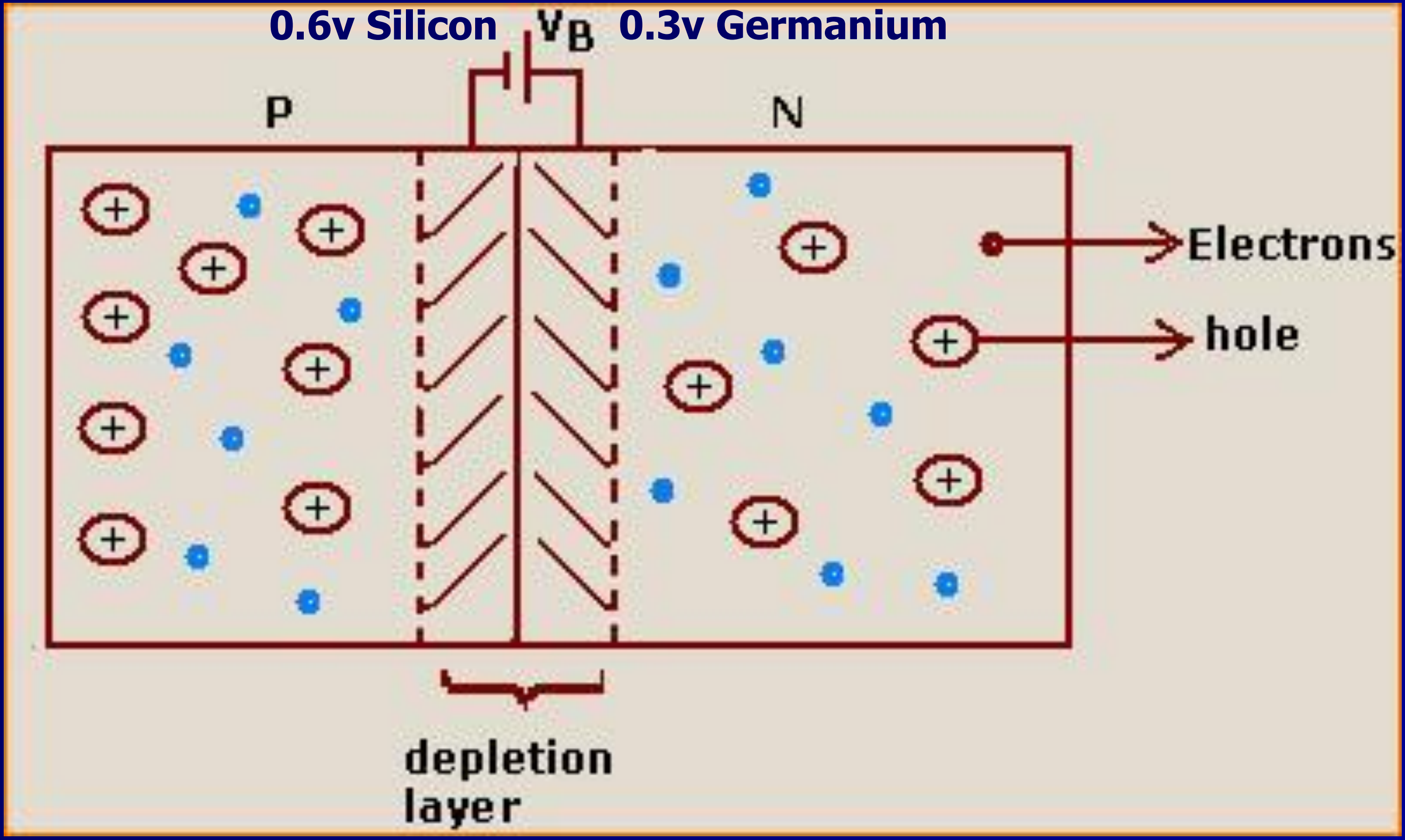
Diode

This semiconductor device is produced by placing the P type and N type semiconductor together.

This results in some of the electrons from the N material jumping over to fill some of the holes in the P material.

This results in a small region forming where the materials touch known as the depletion layer.

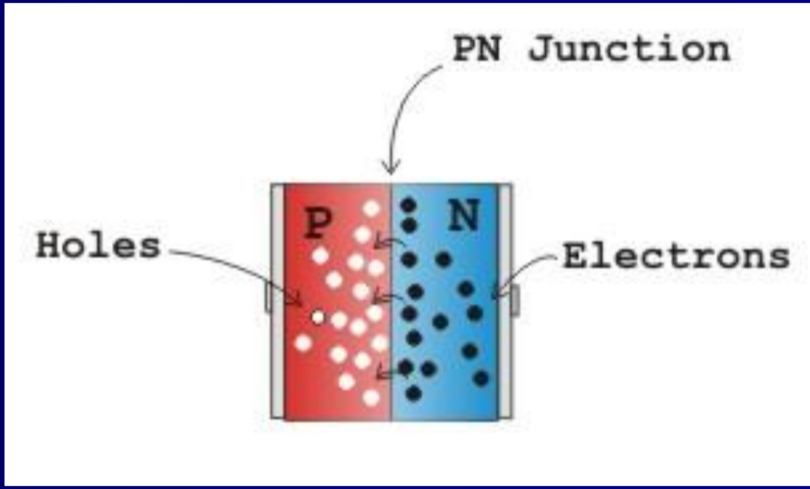
P N Junction



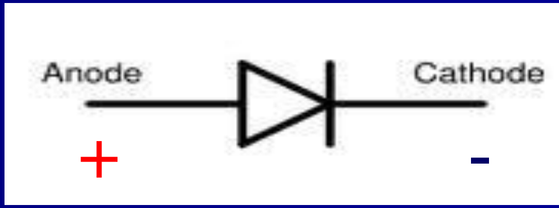
0.6v Silicon
V_B
0.3v Germanium
P
N
Electrons
hole
depletion layer

Depletion Layer

This depletion layer has a direct effect upon which direction current can flow through the junction. The PN junction diagram shown below indicates a barrier that has in fact been created by its depletion layer at the junction between the two materials



DI ODE



Forward Biased Junction Diode

When a diode is connected in **Forward Bias**

i.e. negative side of a voltage is applied to the N-type material (Cathode) and a positive to the P-type material (Anode).

And this external voltage becomes greater than the value of the potential barrier, approx for silicon.

0.6 – 0.7 volts

& for germanium

0.3 volts

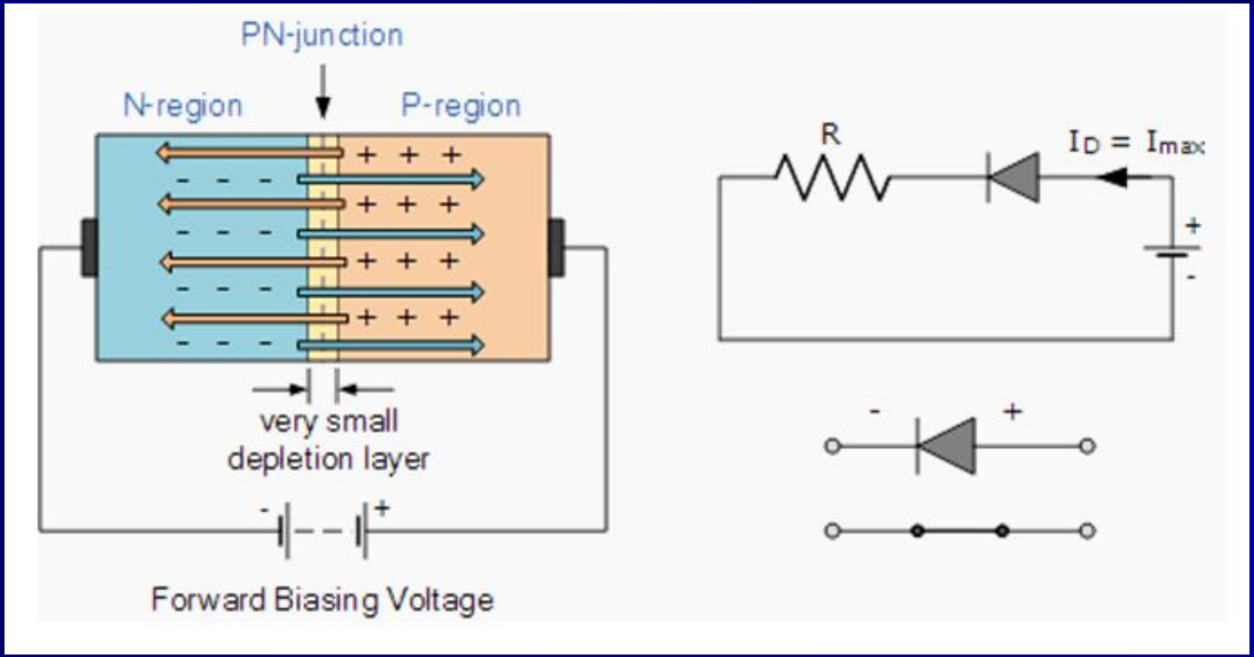
The potential barriers opposition will be overcome and current will start to flow.

Forward Biased Junction Diode

This results in a graphical characteristics curve of zero current flowing up to this voltage point, called the "knee‟

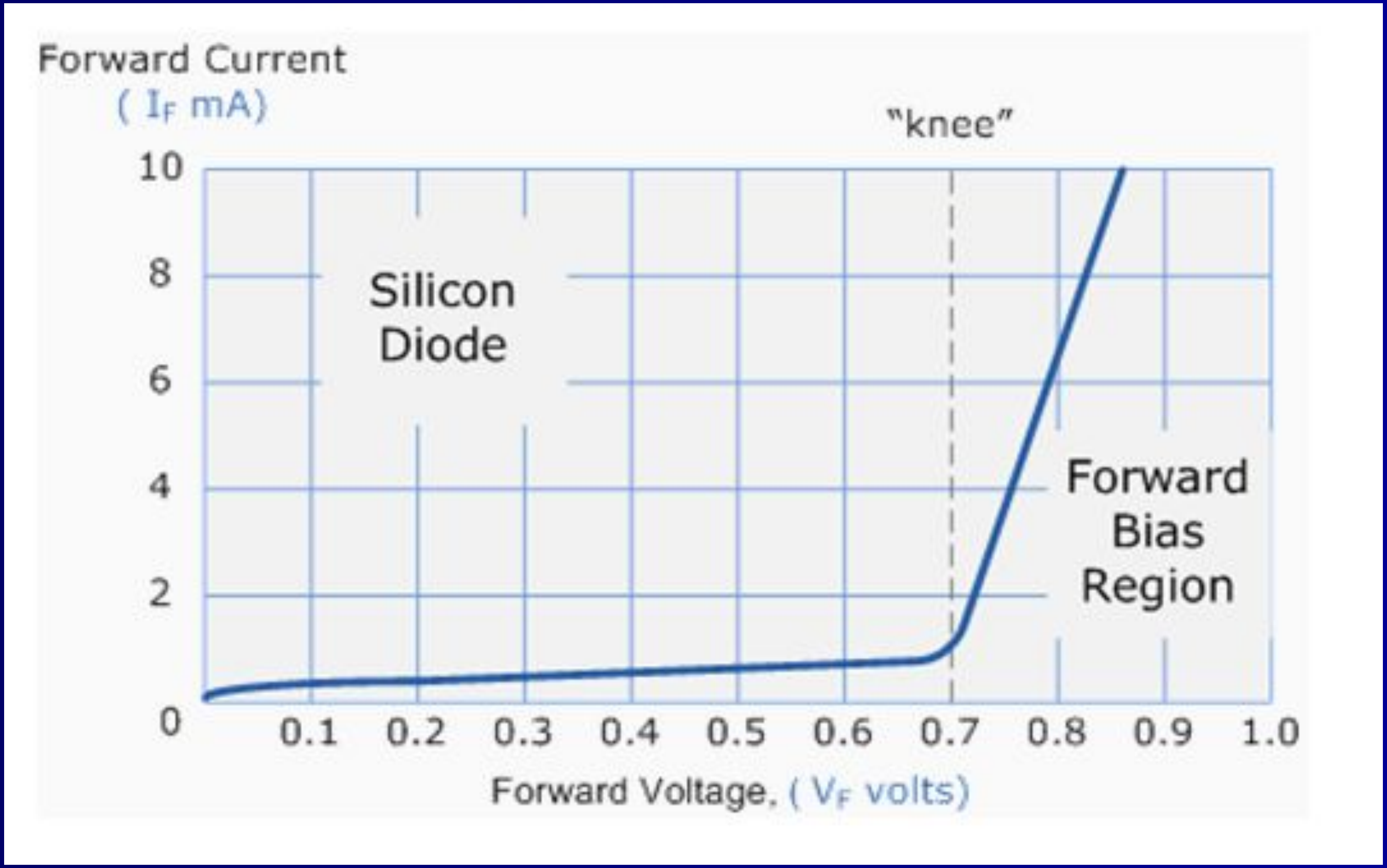
And then a high current flows through the diode for little increase in the external voltage.

Forward Characteristics

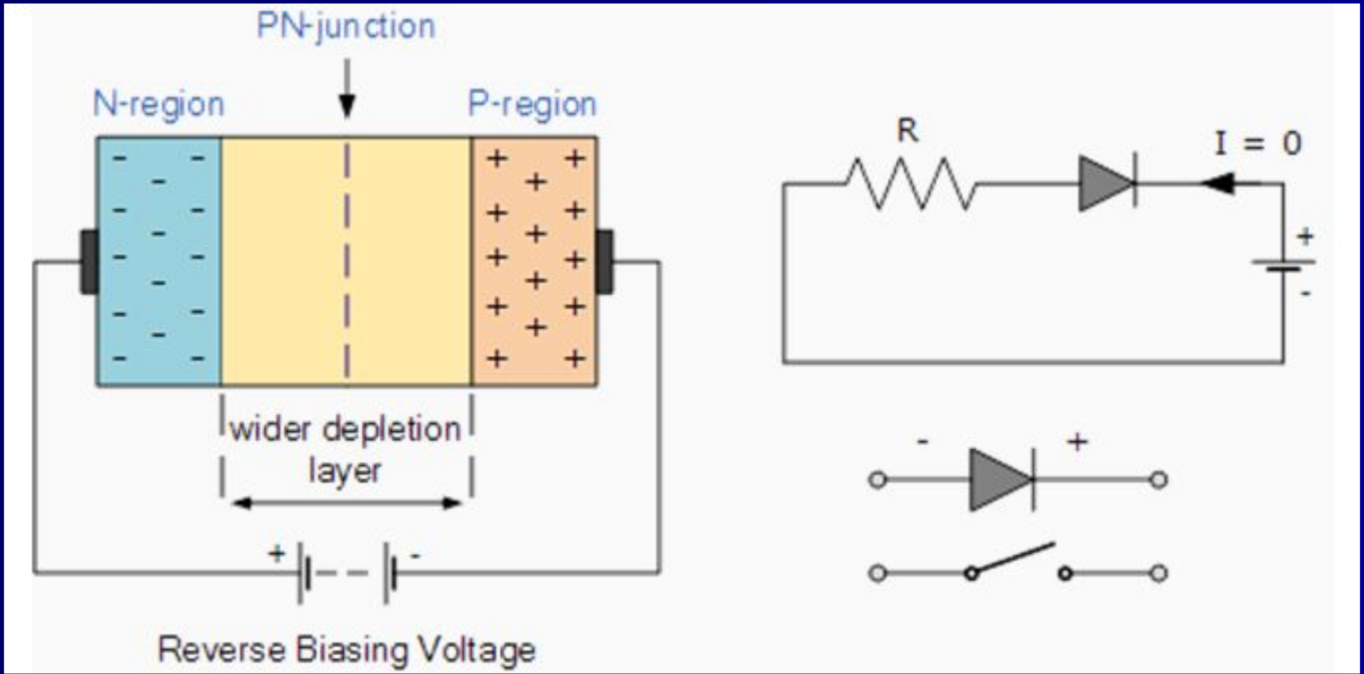


The application of a forward biasing voltage on the junction diode results in the depletion layer becoming very thin and narrow, which represents a low resistance path through the junction thereby allowing currents to flow.

Forward Characteristics

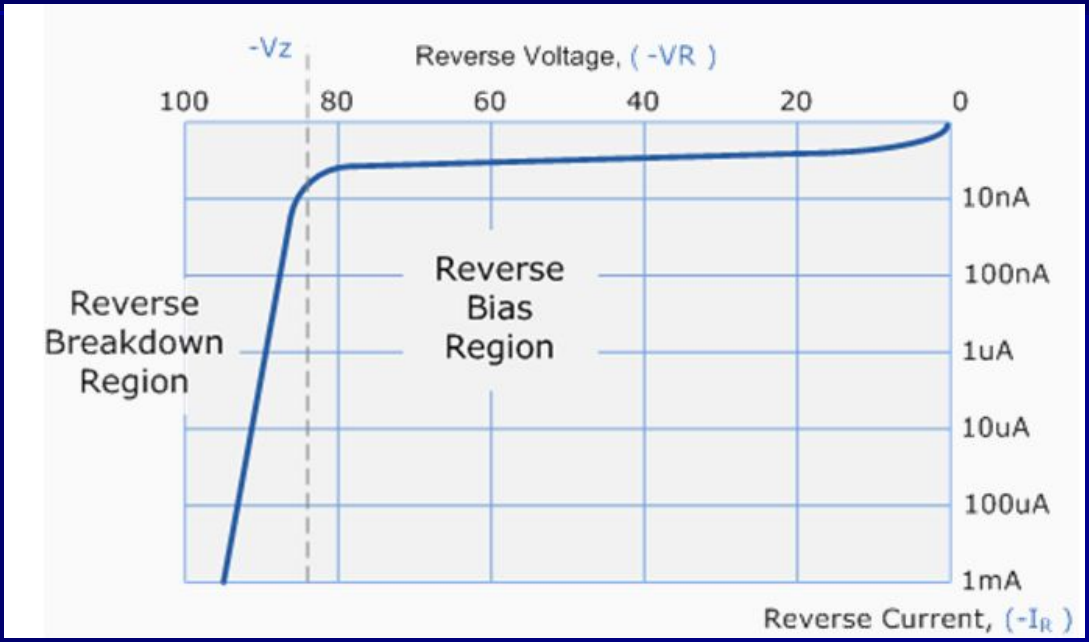


Reverse Characteristics



This condition represents a high resistance value to the PN junction and practically, zero current flows through the junction diode with an increase in bias voltage

Breakdown Characteristics



If the reverse bias voltage -Vr applied to the diode is increased to a sufficiently high enough value, it will cause the PN junction to overheat and fail due to the avalanche effect around the junction. This may cause the diode to become short circuited and will result in the flow of maximum circuit current.

Reverse Biased Junction Diode

When a diode is connected in **Reverse Bias**

i.e. positive side of a voltage is applied to the N-type material (Cathode) and a negative to the P-type material (Anode).

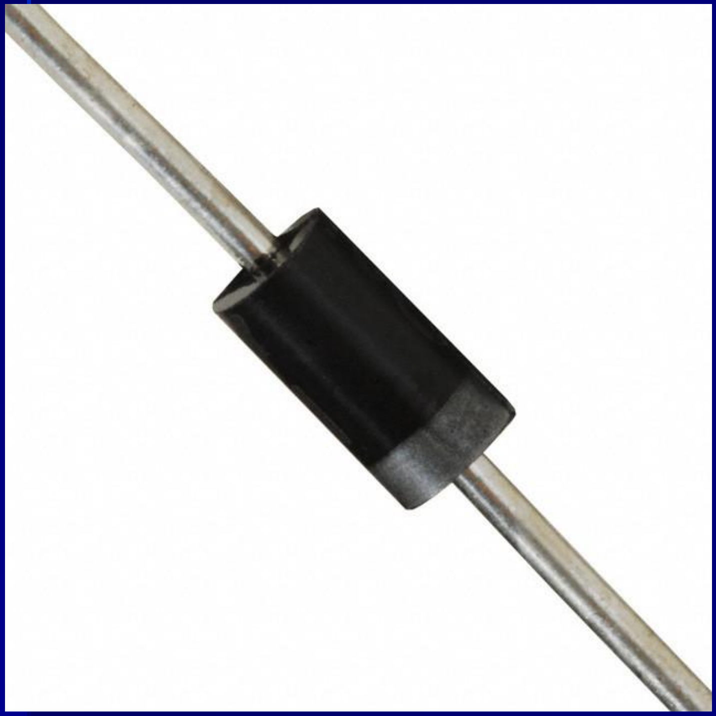
Under this condition the positive electrode attracts **electrons** away and the negative electrode attracts **holes** away from the junction.

The net result is that the depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator.

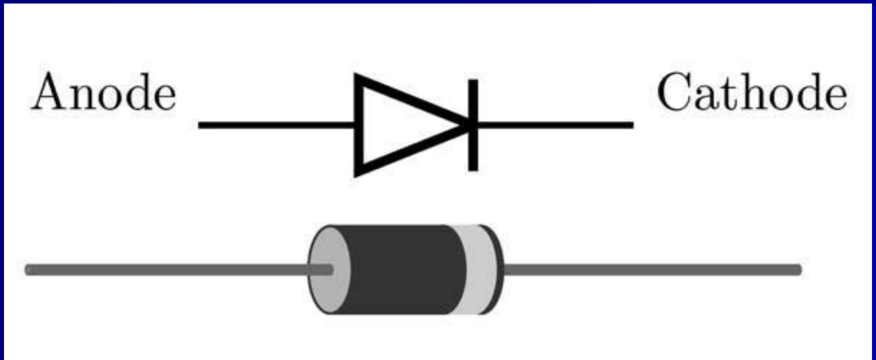
The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.


Si
P
Si
n-type

Types of Diodes

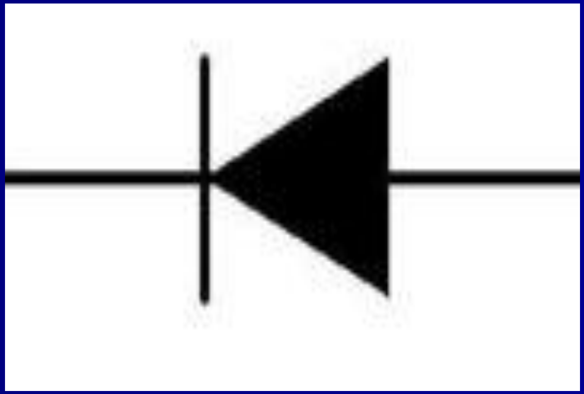


IN4007 General purpose low power



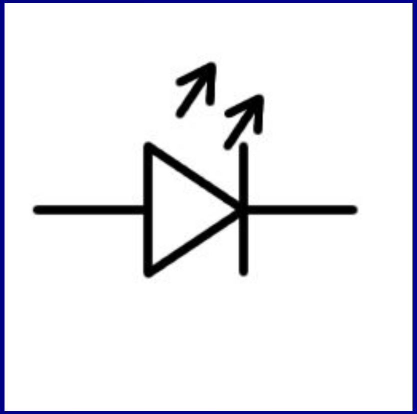
Types of Diodes

Rectifier Diode: These diodes are used to rectify alternating power inputs in power supplies. They can rectify current levels that range from an amp upwards. Generally these diodes are PN junction diodes. Think of a diode as a one way valve!



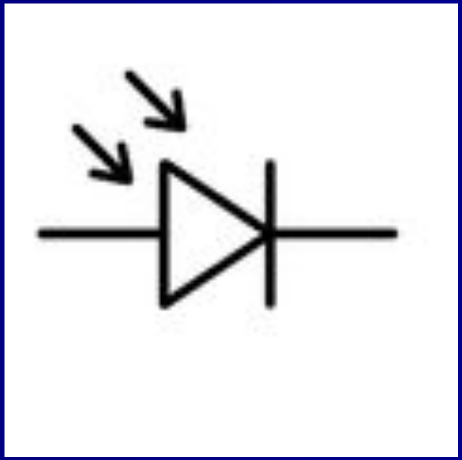
Types of Diodes

Light Emitting Diode (LED): Light is produced when current flows between the electrodes. In most of the diodes, the light (infrared) cannot be seen as they are at frequencies that do not permit visibility. When the diode is switched on or forward biased, the electrons recombine with the holes and release energy in the form of light (electroluminescence). The colour of light depends on the energy gap of the semiconductor.



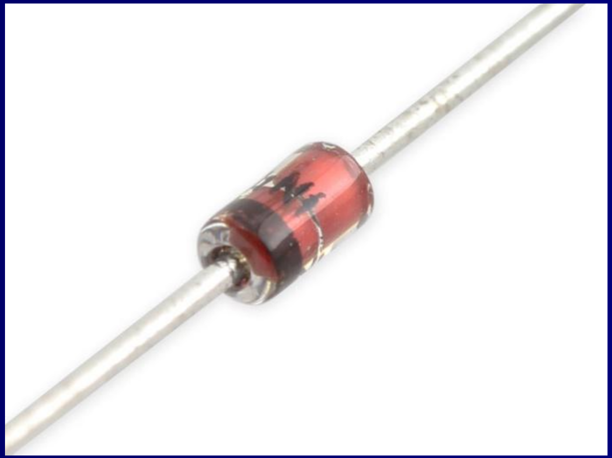
Types of Diodes

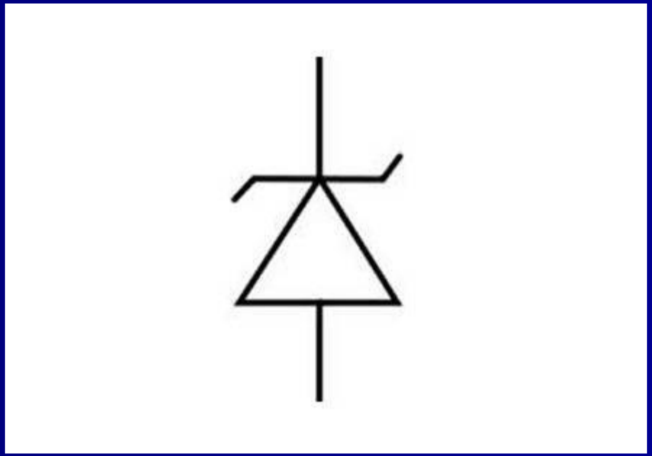
Photodiode: Photodiodes are used to detect light. Generally, these diodes operate in reverse bias mode, when small amounts of current flow, resulting in light being detected with ease. Photodiodes can also be used to generate electricity and hence used in solar cells and in photometry.



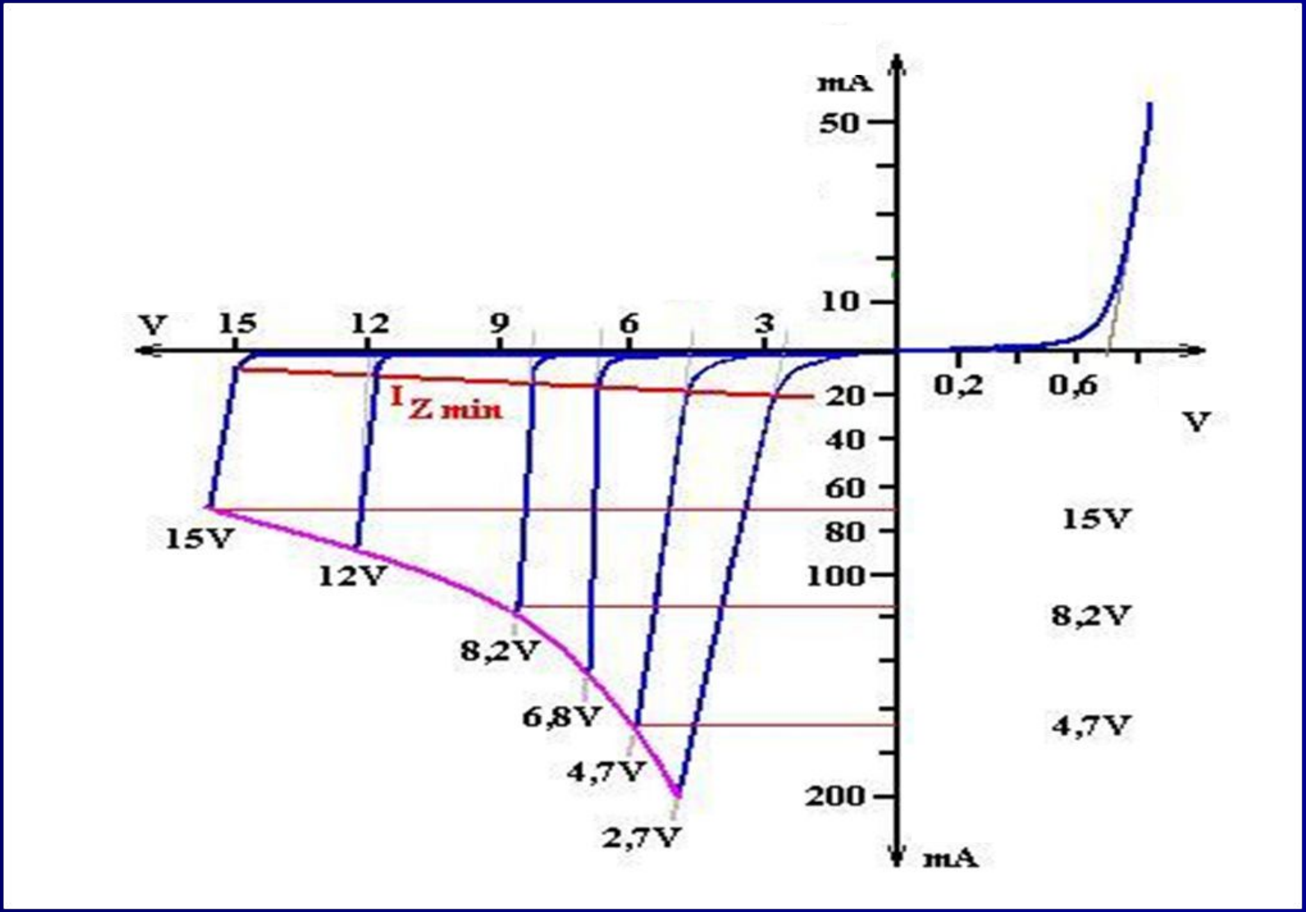
Types of Diodes

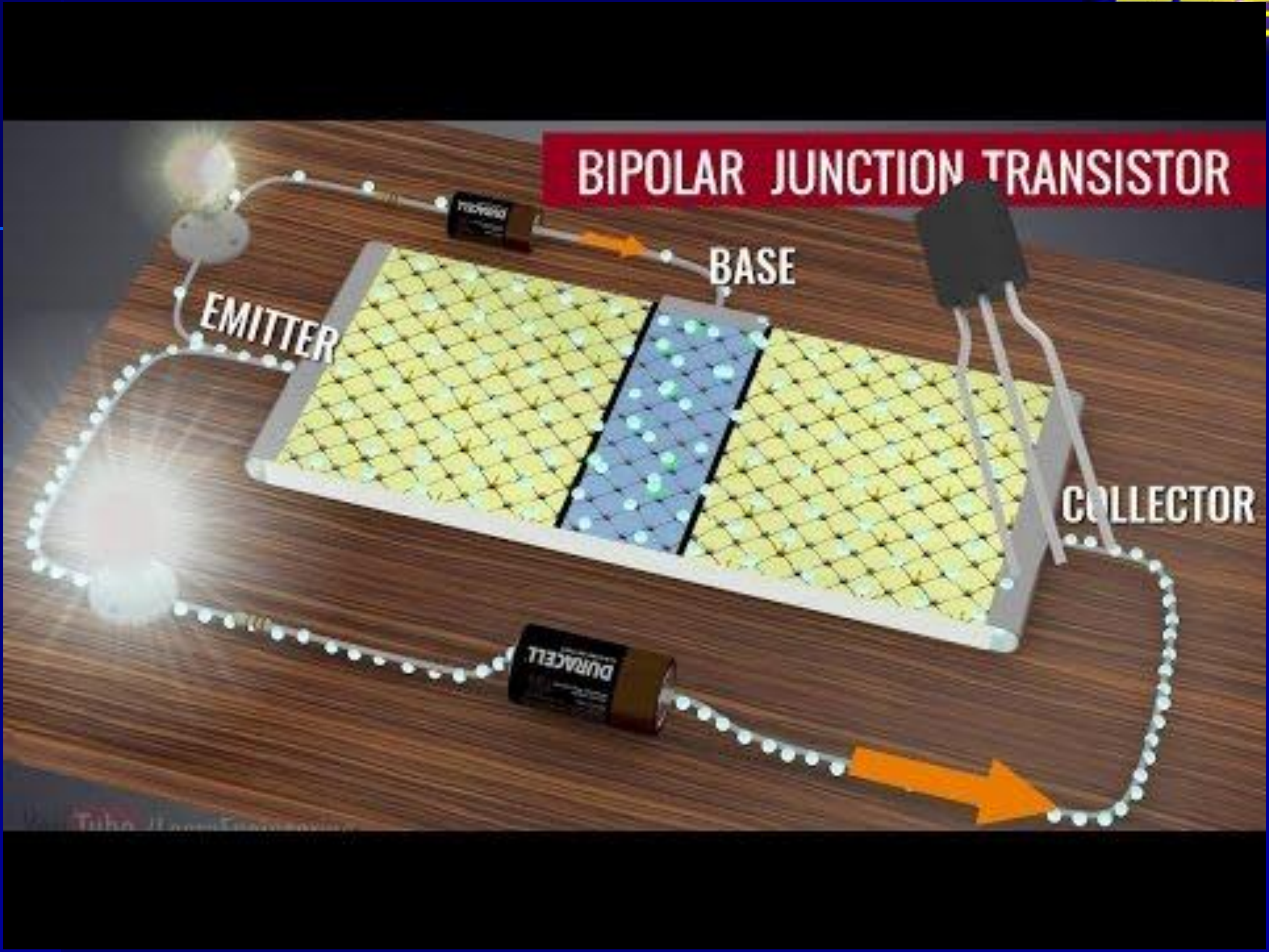
Zener diode: This type of diode provides a stable reference voltage, thus is a very useful type. The diode runs in reverse bias, and breaks down on the arrival of a certain voltage. A stable voltage is produced, if the current through the resistor is limited. In power supplies, these diodes are widely used to provide a reference voltage.



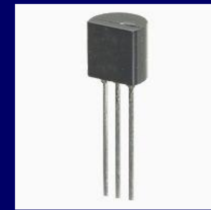


Zener Breakdown Voltage

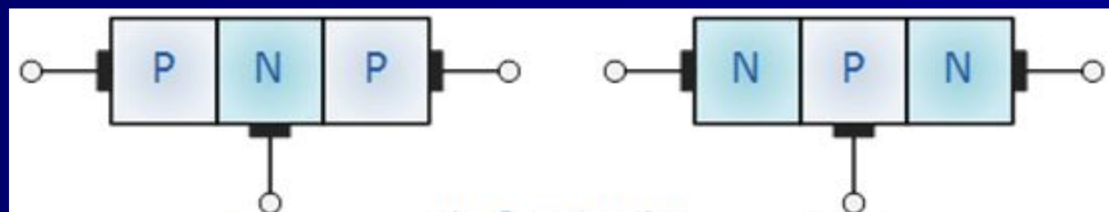



BIPOLAR JUNCTION TRANSISTOR
BASE
EMITTER
COLLECTOR

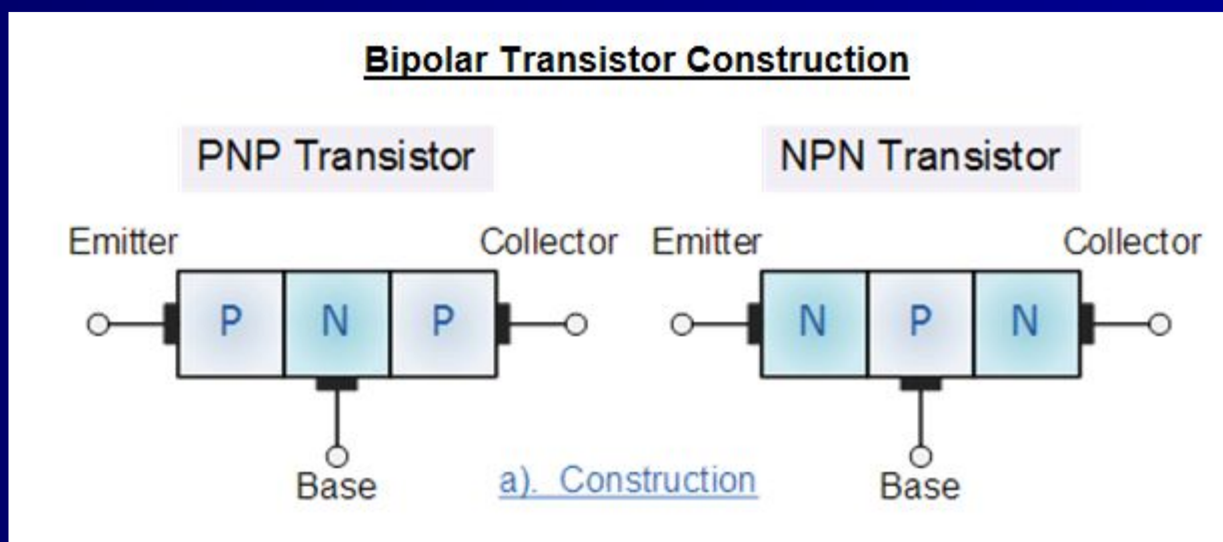
Transistors



These devices combine three doped semiconductor materials and can therefore be PNP or NPN

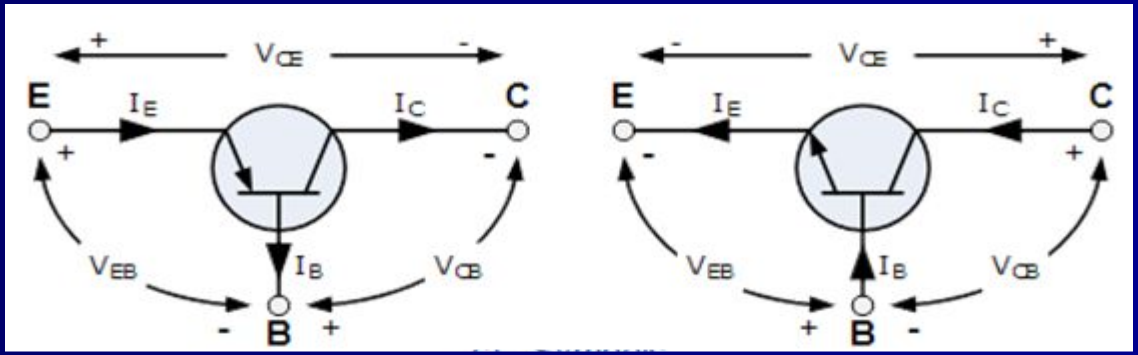


In this configuration we get three terminal connections called the Base, Collector and Emitter

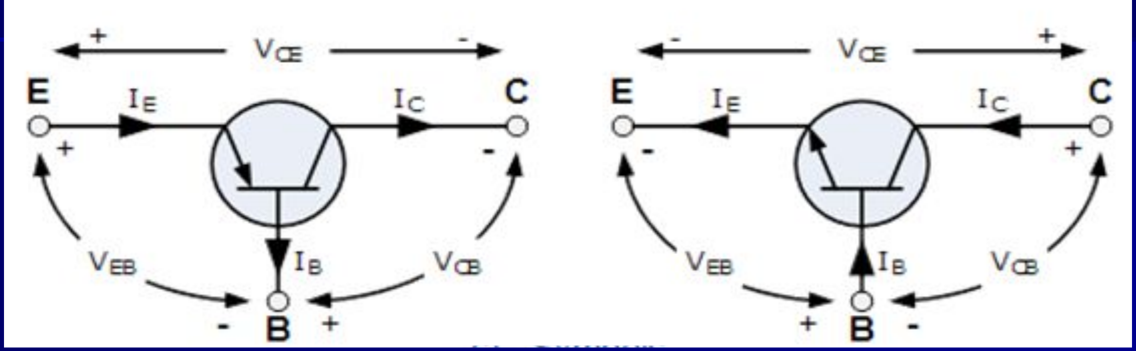


Transistors

Bipolar Transistors are current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing voltage applied to their base terminal acting like a current-controlled switch. The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type.



Transistor Symbols



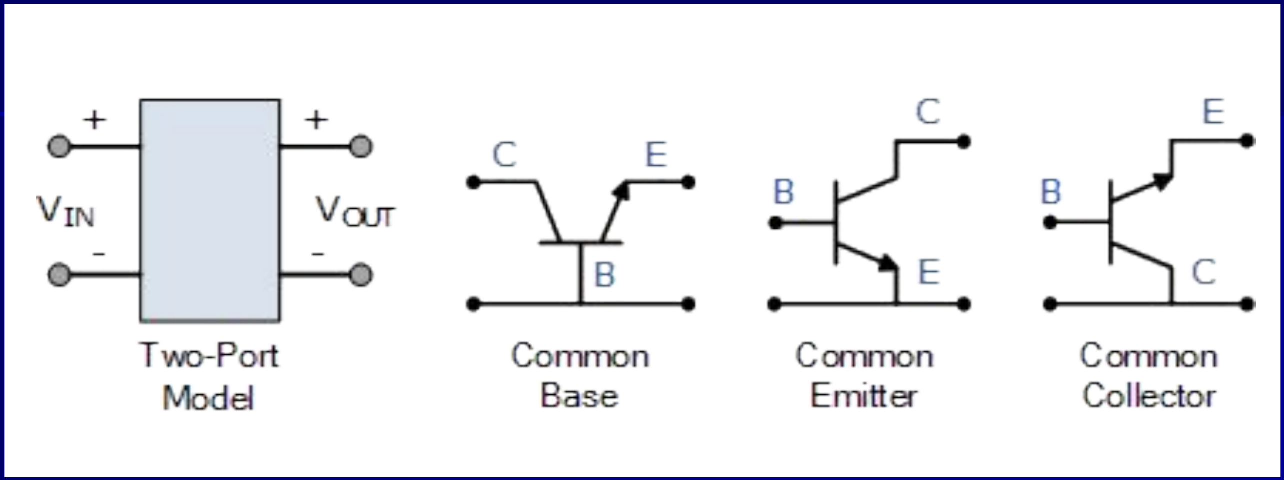
The construction and circuit symbols for both the PNP and NPN bipolar transistor are given above with the arrow in the circuit symbol always showing the direction of "conventional current flow" between the base terminal and its emitter terminal. The direction of the arrow always points from the positive P-type region to the negative N-type region for both transistor types, exactly the same as for the standard diode symbol.

Configuration

As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor varies with each

1. Common Base Configuration
2. Common Emitter Configuration
3. Common Collector Configuration

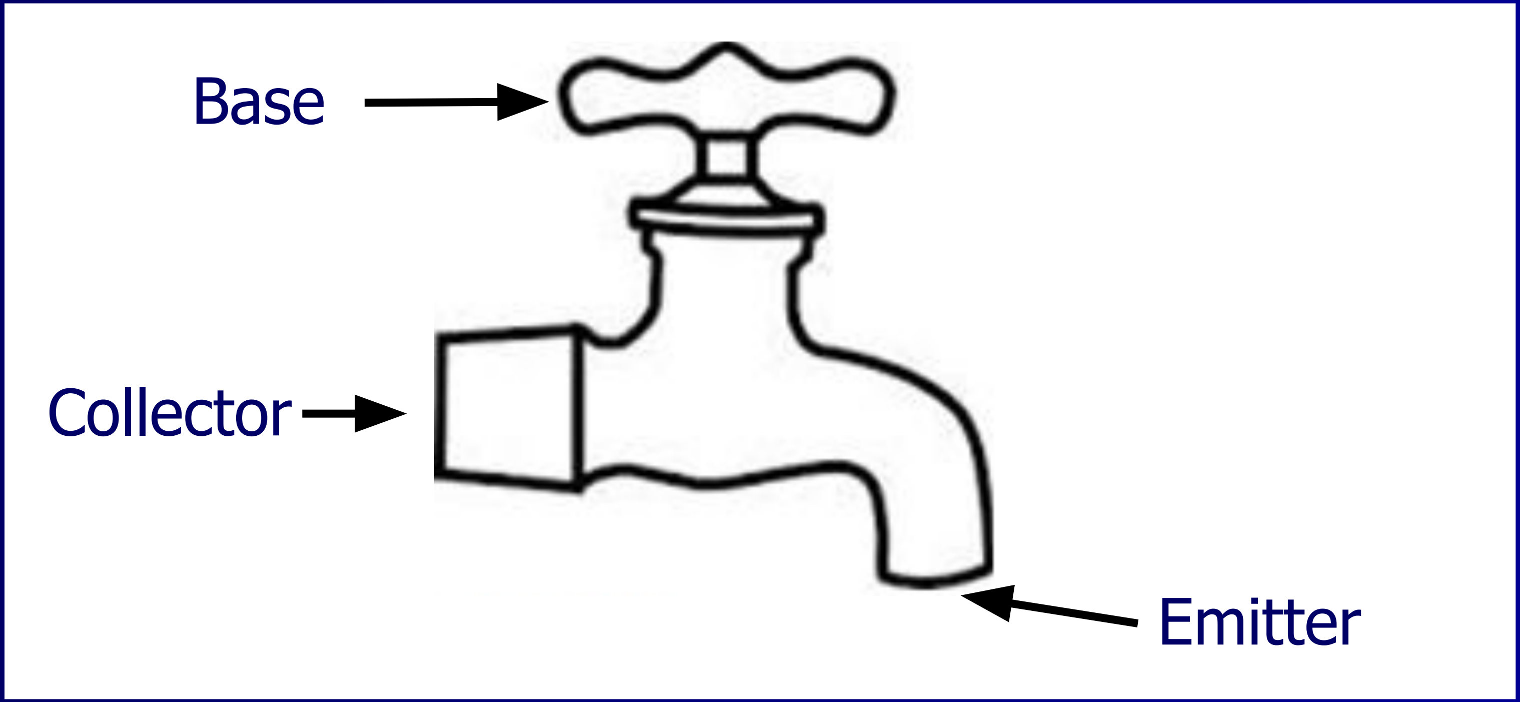
Configuration



Characteristic	Common Base	Common Emitter	Common Collector
Input Impedance	Low	Medium	High
Output Impedance	Very High	High	Low
Phase Angle	0°	180°	0°
Voltage Gain	High	Medium	Low
Current Gain	Low	Medium	High
Power Gain	Low	Very High	Medium

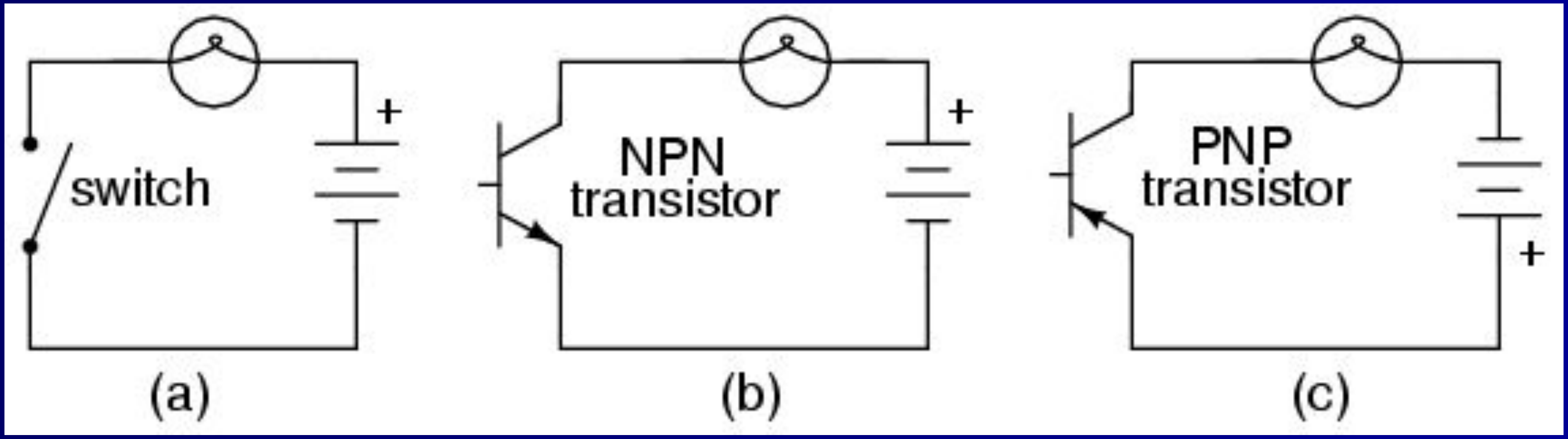
Analogy

Think of it as a **water tap** where the main flow is controlled by the small amount of pressure applied to the gate valve.



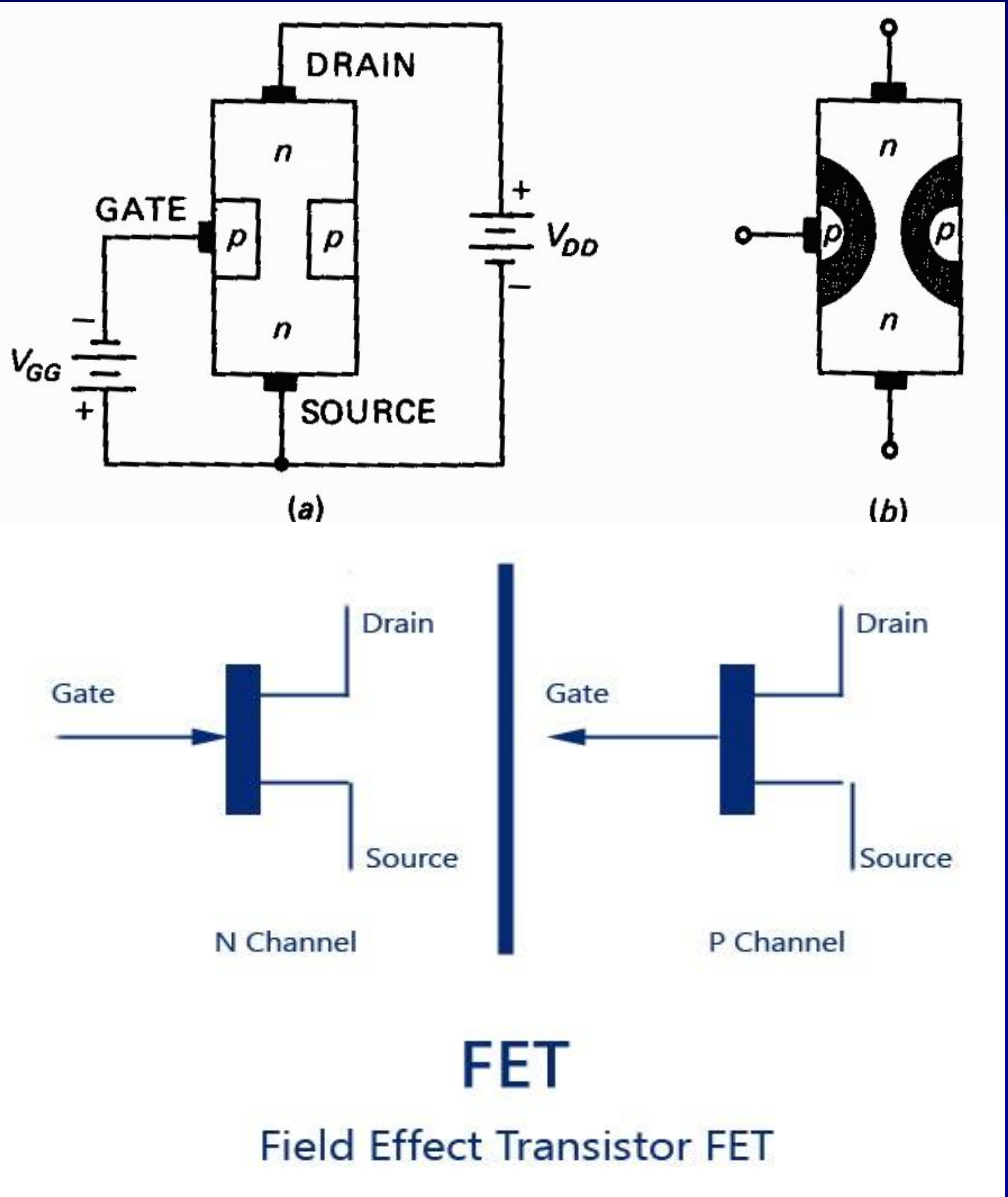
Transistor as a Switch

Because a transistor's collector current is proportionally limited by its base current, it can be used as a sort of current-controlled switch. A relatively small flow of electrons sent through the base of the transistor has the ability to exert control over a much larger flow of electrons through the collector.



Feild Effect Transistor FET

FET is made of three terminals known as ‘Gate’, ‘Source’ and ‘Drain’. Here drain current is controlled by the gate voltage. Therefore, FETs are voltage controlled devices.



Difference between BJT and FET

Bipolar Junction (BJT) is basically a current driven device, though FET is considered as a voltage controlled device.

Terminals of BJT are known as emitter, collector and base, whereas FET is made of gate, source and drain.

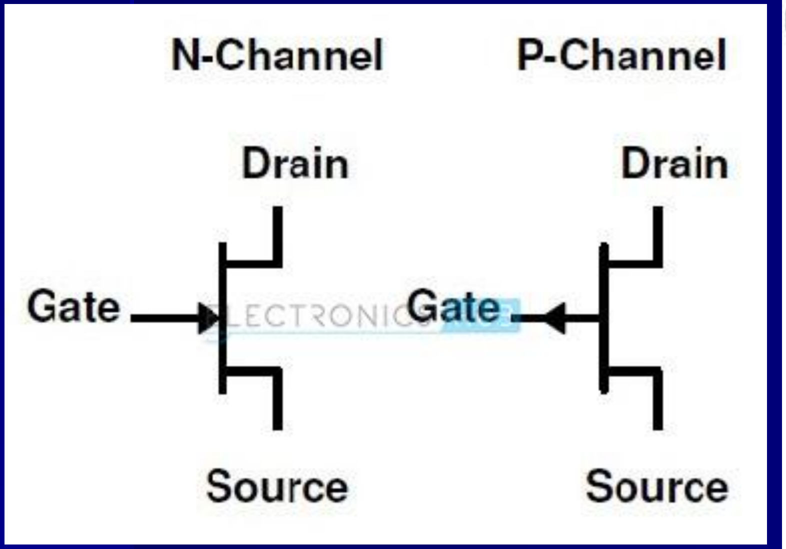
In most of the new applications, FETs are used than BJTs.

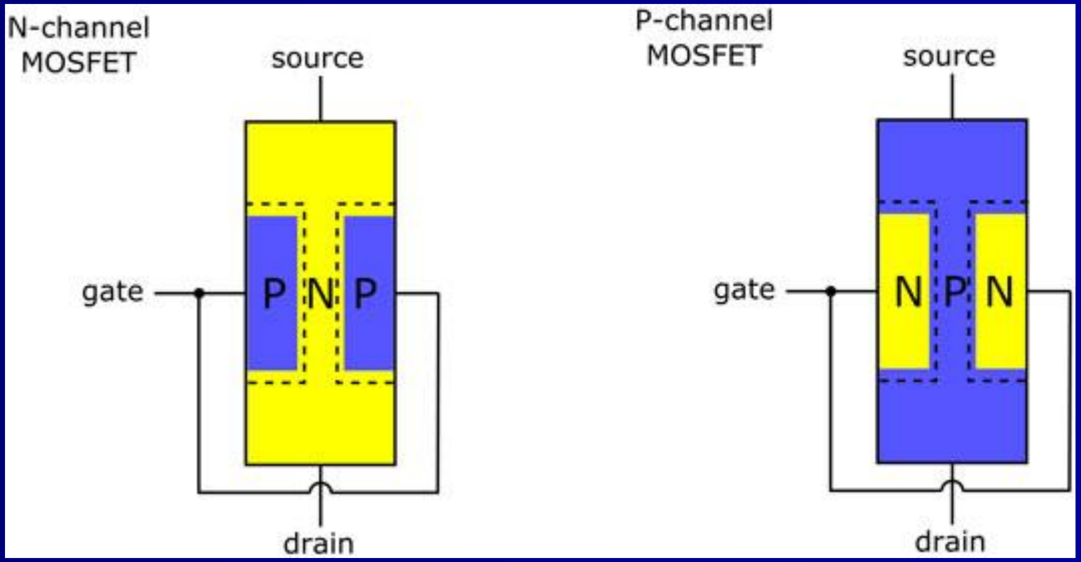
FET can be made quite small as compared to BJT.

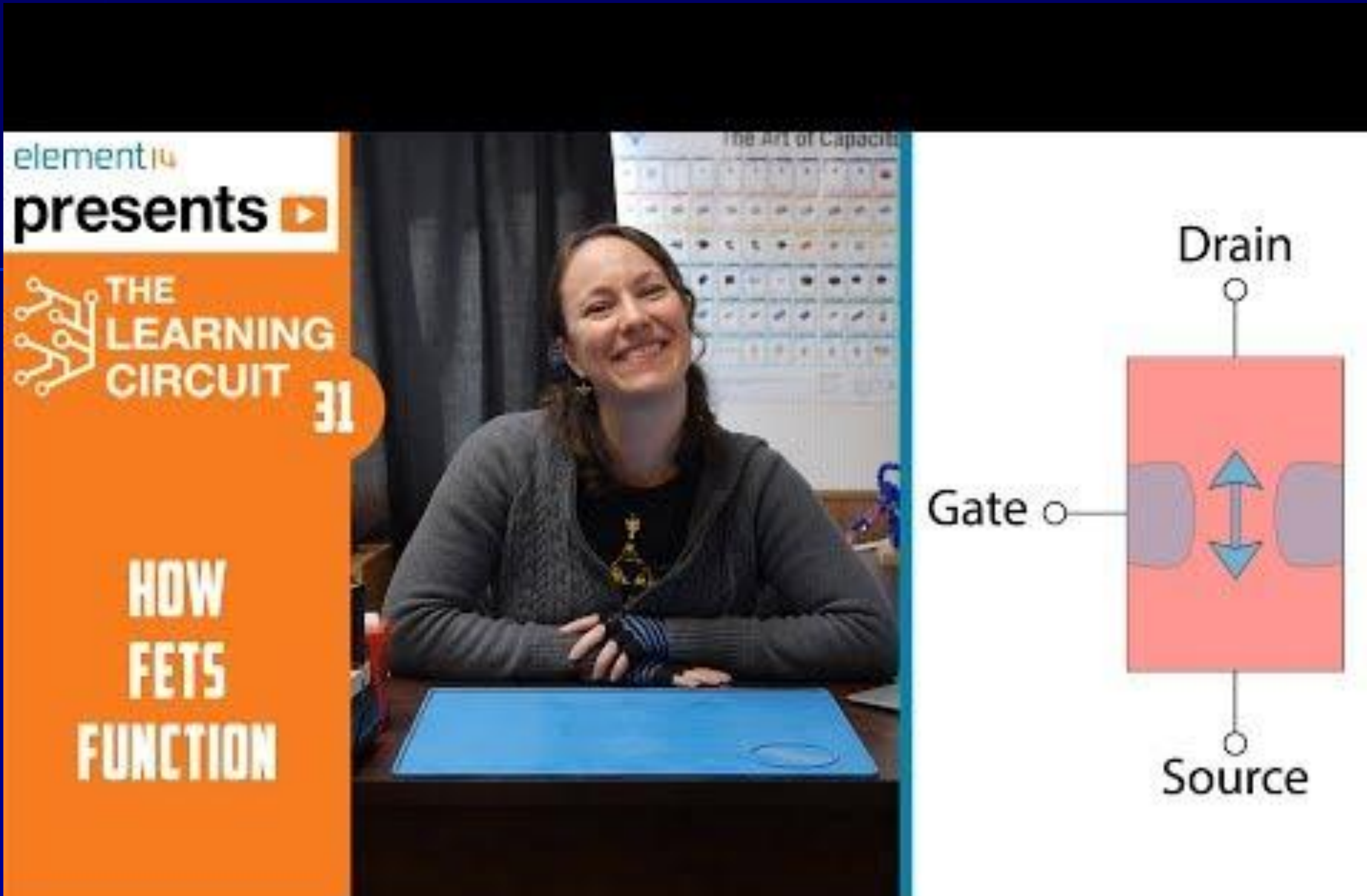
FETs are more power efficient than BJTs.

FETs are more widely used and more popular than BJTs. FETs can be manufactured smaller and load the power supply less.

FET
N- Channel and P-Channel






element14
presents
THE LEARNING CIRCUIT 31
HOW FETS FUNCTION
Drain
Gate
Source