

Engineering Physics

Session 1



Marwadi
University

Department of
Mechanical Engineering

Unit no. 1
Electronic Materials
Physics (01GS1101)

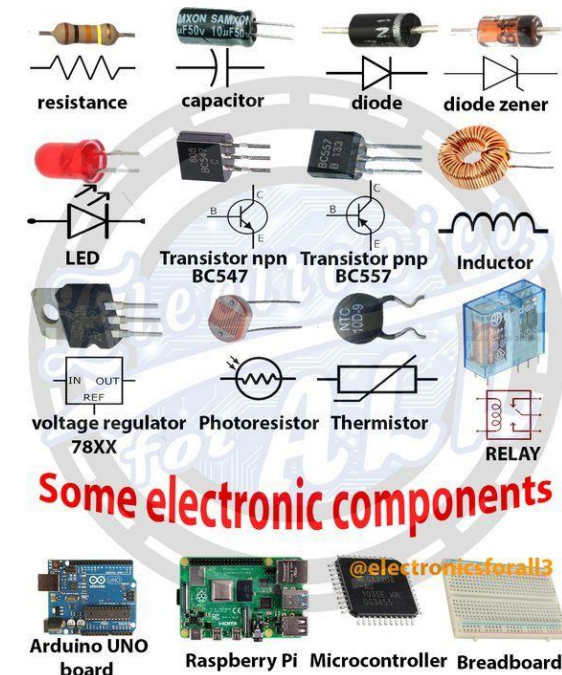
Dr. Parag Rajpara

Electronic materials

- Electronic materials are materials studied and used mainly for their electrical properties.
- The electric response of materials largely stems from the dynamics of electrons, and their interplay with atoms and molecules.
- Electronic materials are probably typified by the materials used to construct a semiconductor chip.
- A chip contains a complicated combination of materials like semiconductors, insulators, metallic materials, etc.
- Electronic materials, as a group, include semiconductors, metals, polymers, ceramics, and composites that are used to construct highly complex functional sub-systems and systems such as integrated electronic circuits, magnetic and optical storage media, communication devices, sensors, flat panel displays, lasers, batteries, fuel cells, just to name a few.

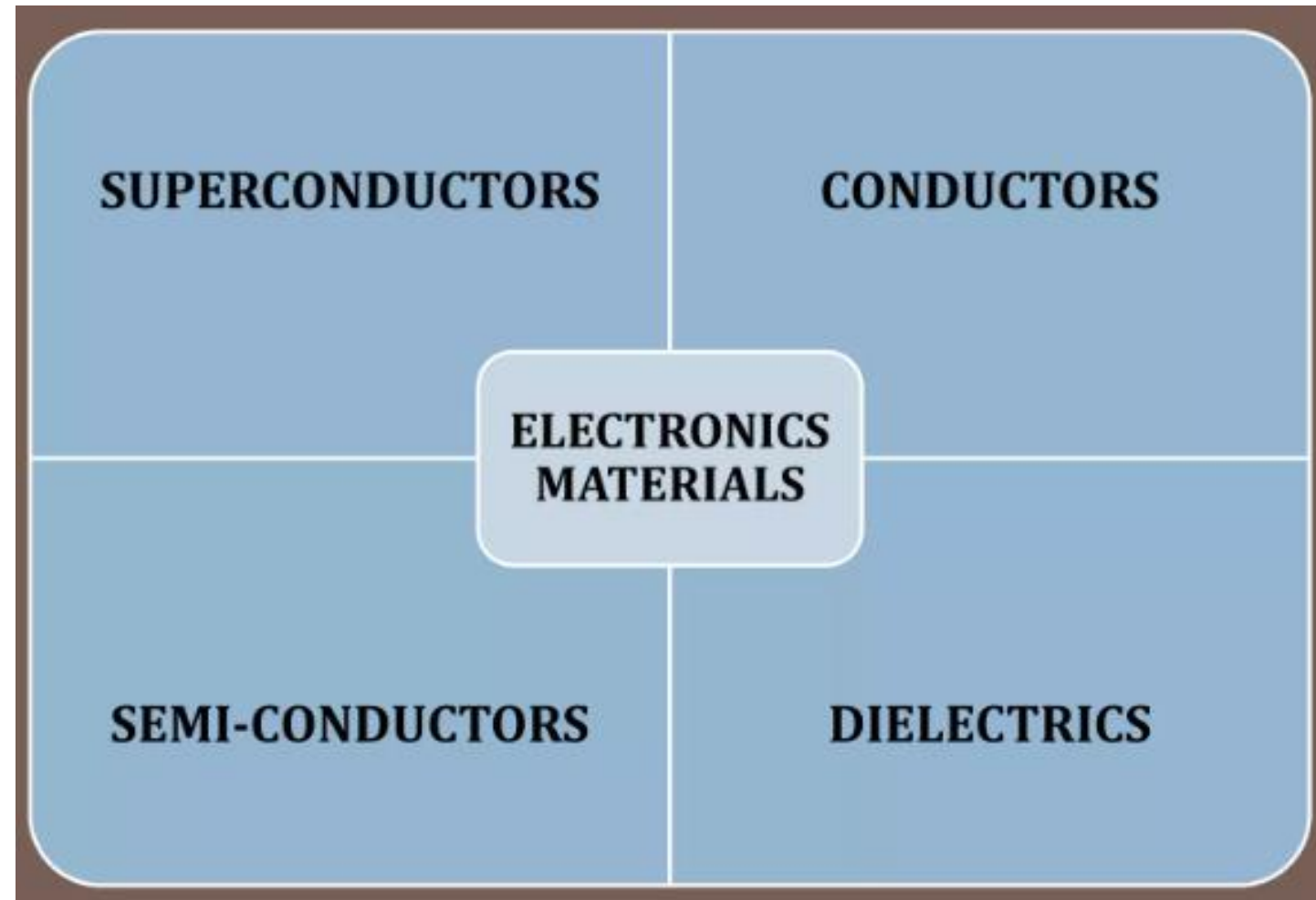
Electronic materials

- Now a days Electronic materials are universal. Literally, billions of people are using electronic materials in their daily life.
- Our communication devices, computing devices, etc. that we take for granted today are basically built with complex combination of electronic materials.
- Electronic materials have been the basis for the current age of electronics, information and communication technology, and have been contributing to worldwide economic growth in a big way.



Types of Electronic materials

Classification of electronic materials



Types of Electronic materials

Classification of electronic materials

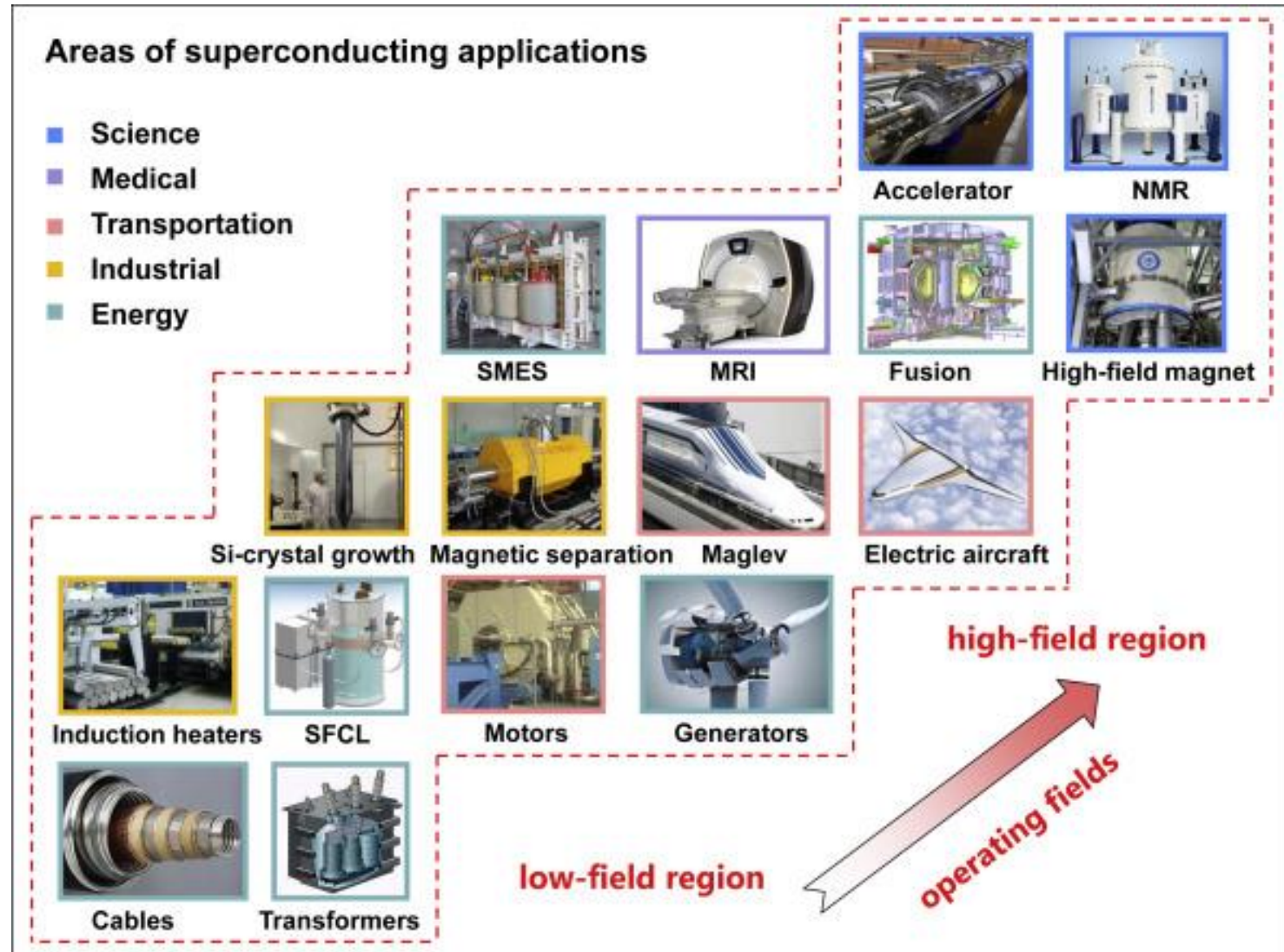
1. *Superconductors*

- A superconductor is a material that can conduct electricity or transport electrons from one atom to another with no resistance.
- Some of the superconductor materials include **single elements** like mercury and lead, **alloys** like niobium-titanium, germanium-titanium and niobium-nitride and **ceramics** such as YBCO and magnesium diboride.
- Superconductors are already used in many fields such as
 - ✓ Electricity
 - ✓ Medical applications
 - ✓ Electronics
 - ✓ Trains
 - ✓ Laboratories
 - ✓ Superconducting coils to produce very strong magnetic fields

Types of Electronic materials

Classification of electronic materials

1. *Superconductors*



Types of Electronic materials

Classification of electronic materials

2. *Conductors*

- A conductor is an object or type of a material that allows the flow of electrical current in one or more directions.
- A wire is an electrical conductor that can carry electricity along its length.
- Some of the conductors are metals, electrolytes, superconductors, semiconductors nonmetallic conductors such as graphite and conductive polymers.



Types of Electronic materials

Classification of electronic materials

2. *Conductors*

- Some of the products of conductors include
 - ✓ switchyards,
 - ✓ collector yards,
 - ✓ transmission lines,
 - ✓ distribution lines and
 - ✓ underground utility systems.

Switchyard



Transmission lines



Underground utility system



Classification of electronic materials

3. *Semiconductors*

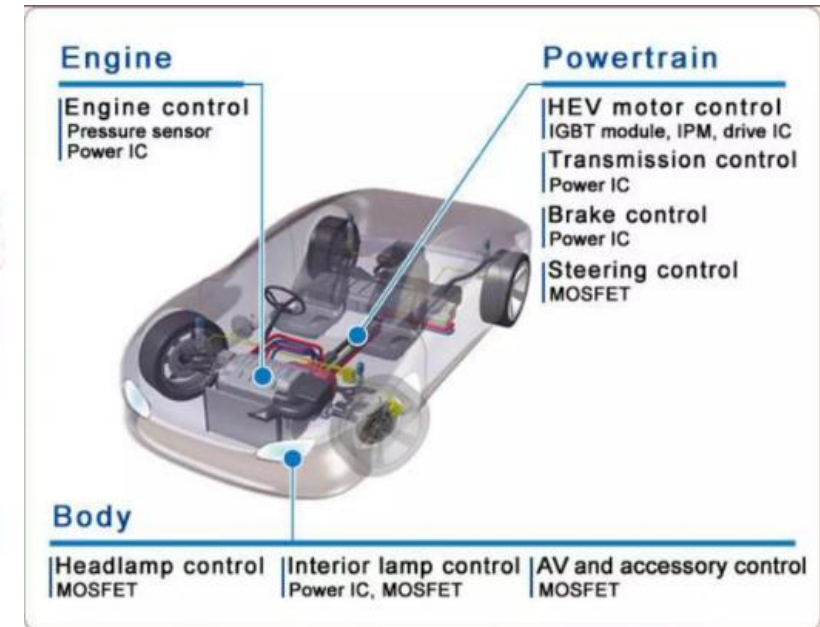
- Semiconductors are those materials whose conductivities lie between conductors and insulators.
- They have poor conductivity than conductors and higher than insulators.
- Therefore, they are neither good conductors nor good insulators.
- When temperature of semiconductor is increased, its resistivity is decreased or conductivity is increased.
- At higher temperature, a semiconductor conducts better.
- Some of examples of semiconductors include silicon, germanium and gallium arsenide.

Types of
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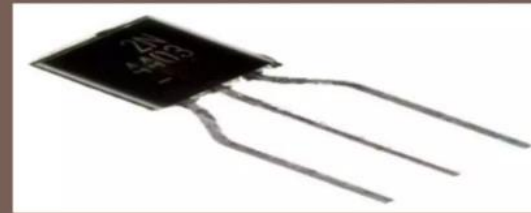
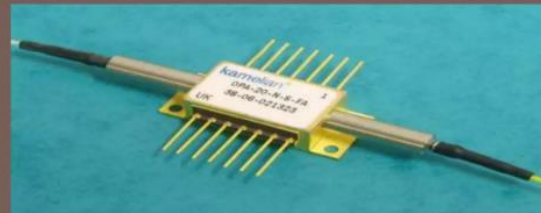
Classification of electronic materials

3. Semiconductors

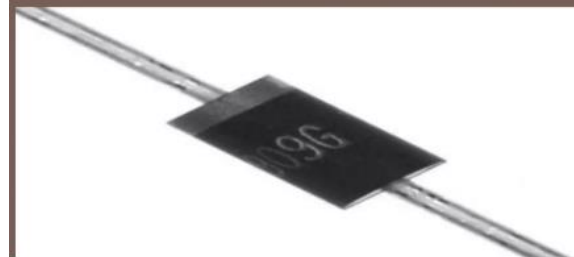
Types of Electronic materials



SEMICONDUCTOR OPTICAL AMPLIFIER SEMICONDUCTOR TRANSISTOR



SEMICONDUCTOR DIODES



SEMICONDUCTOR LASERS



Types of Electronic materials

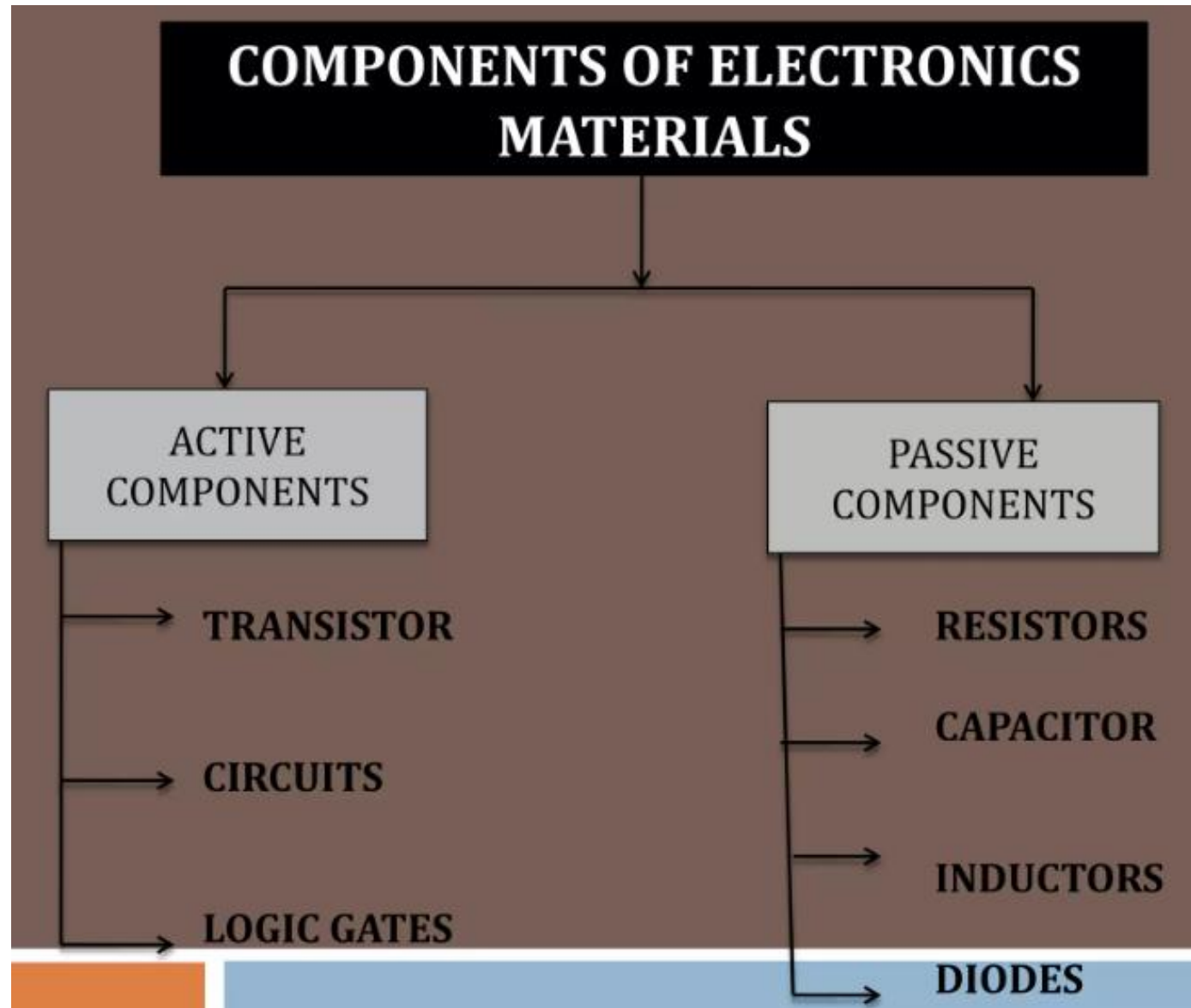
Classification of electronic materials

4. *Dielectrics*

- A dielectric material is an electrical insulator that can be polarized by an applied electric field.
- When a dielectric is placed in an electric field, electric charges do not flow through the material as they do in a conductor, but only slightly shift from their average equilibrium positions causing dielectric polarization.
- Several materials such as Al_2O_3 , SiO_2 , ZrO_2 , porcelain, glass and some plastics are examples of dielectrics.
- Some of the products of dielectric are capacitors, dielectric resonator oscillator, sensor devices and insulation of wires and cables.

Components of Electronic materials

Components of electronic materials

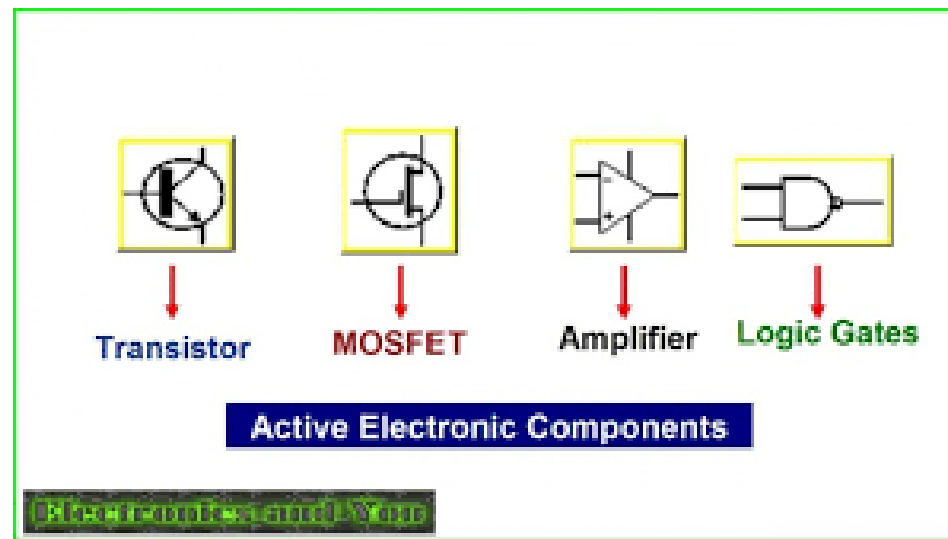


Components of Electronic materials

Components of electronic materials

1. *Active components*

- Active components are components that can generate, amplify and even controls the current in a circuit.



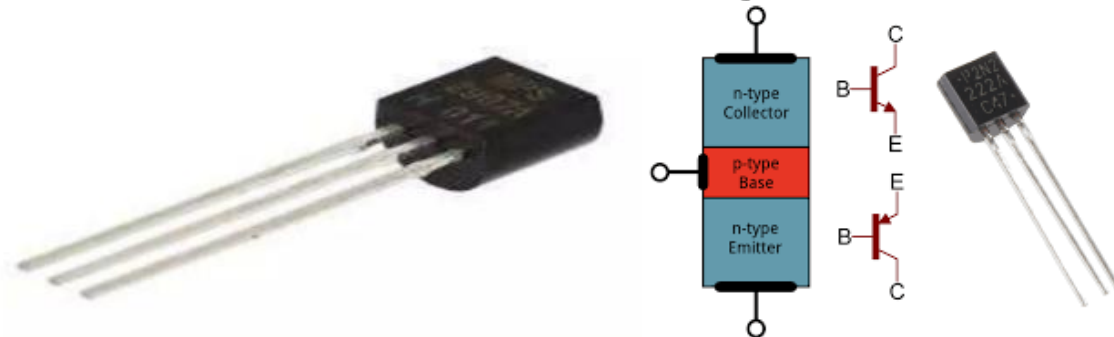
Components of Electronic materials

Components of electronic materials

1. *Active components*

❖ Transistor

- A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power.
- Transistors are also used for low-frequency, high-power applications, such as power-supply inverters that convert alternating current into direct current. Additionally, transistors are used in high-frequency applications, such as the oscillator circuits used to generate radio signals.





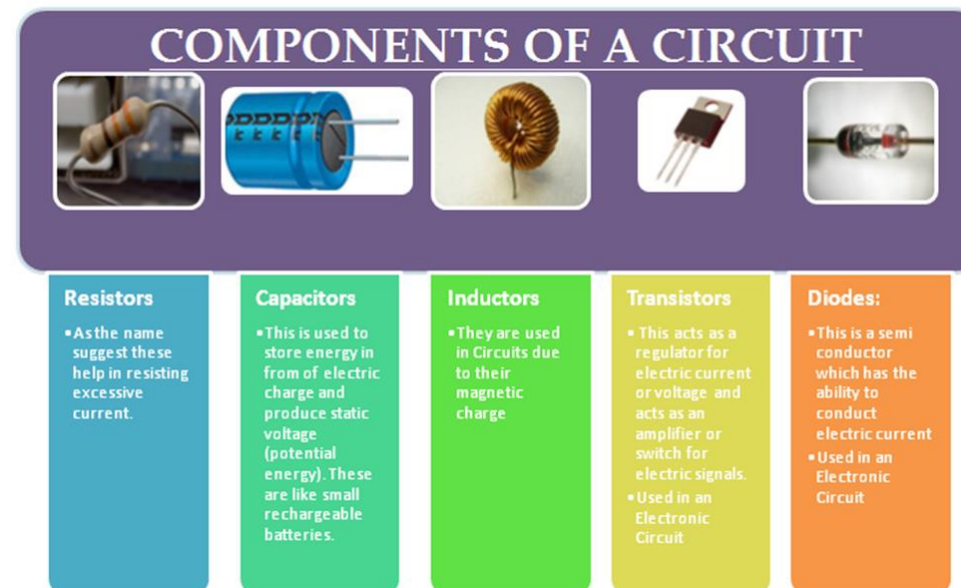
Components of Electronic materials

Components of electronic materials

1. *Active components*

❖ **Circuit**

- An electronic circuit is composed of individual electronic components such as
 - Resistors
 - Transistors
 - Capacitors
 - Inductors
 - Diodes
- Electric circuit, path for transmitting electric current.
- An electric circuit includes a device that gives energy to the charged particles constituting the current, such as a battery or a generator; devices that use current, such as lamps, electric motors, or computers; and the connecting wires or transmission lines.



Components of Electronic materials

Components of electronic materials

1. Active components

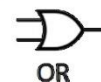
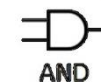
❖ Logic gates

- A logic gate is an elementary building block of a digital circuit.
- Most logic gates have two inputs and one output.
- At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels.
- For example, logic gates can be used in digital electronics such as smartphones and tablets or in memory devices.
- In a circuit, logic gates work based on a combination of digital signals coming from its inputs.



Basic Digital Logic Gates

INPUT		OUTPUT
A	B	
0	0	0
1	0	0
0	1	0
1	1	1



A AND B	$A \cdot B$
A OR B	$A + B$
NOT A	\bar{A}
A XOR B	$A \oplus B$

Components of electronic materials

2. *Passive components*

- Passive components are components that do not generate voltage but controls the current in a circuit.
- A passive element is an electrical component that does not generate power, but instead dissipates, stores, and/or releases it.
- Passive elements include resistances, capacitors, and coils (also called inductors).
- These components are labeled in circuit diagrams as R_s , C_s and L_s , respectively.



Components
of Electronic
materials



Components of Electronic materials

Components of electronic materials

2. *Passive components*

❖ Resistor

- A resistor is a passive two-terminal electronic component that implements electrical resistance as a circuit element.
- Resistor act to reduce current flow, and at the same time, act to lower voltage levels within circuits.
- In electronic circuits, resistors are used to limit current flow to adjust signal levels, bias active elements and terminate transmission lines among other uses.
- Because of the nature of generating heat when conducting current, resistors are used in a heater, toaster, microwave, electric stove, and many more heating appliances.
- In a light bulb, the metal filament glows white-hot due to the very high temperature produced from the resistance when electricity is passed through it.

Components of Electronic materials

Components of electronic materials

2. *Passive components*

❖ Capacitor

- A capacitor is specially used to store energy; they are like a fully charged battery.
- Caps, as we usually refer to them, have all sorts of critical applications including local energy storage, voltage spike suppression, and complex signal filtering.



Components of Electronic materials

Components of electronic materials

2. *Passive components*

❖ Inductors

- An inductor, also called as coil or reactor, is a passive two terminal electronic component which resists changes in electric current passing through it.
- It consists of a conductor such as wire, usually wound on into a coil.
- When a current flows through it, energy is stored temporarily in a magnetic field in the coil.



Components of Electronic materials

Components of electronic materials

2. *Passive components*

❖ Diodes

- A diode is a specialized electronic component with two electrodes called the anode and cathode.
- Most diodes are made with semiconductor materials such as silicon, germanium or selenium.
- Diodes can be used as rectifiers, signal limiters, voltage regulators, switches, signal modulators, signal mixers, signals demodulators and oscillators.

