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(An Autonomous Institution)

COIMBATORE-35

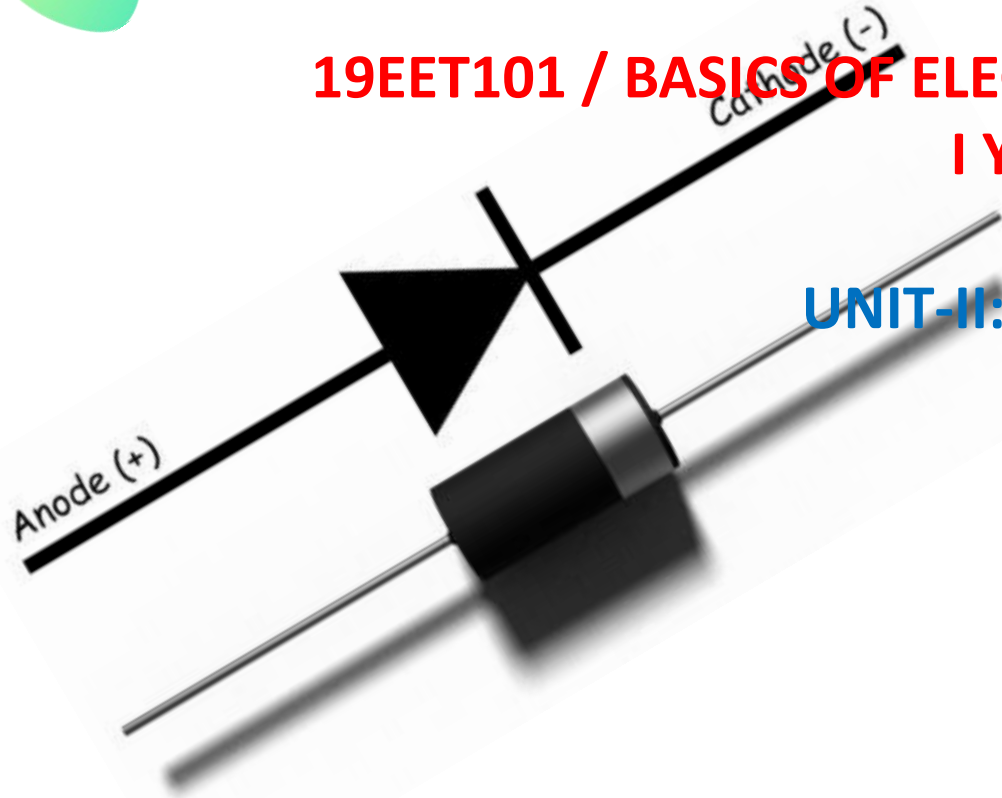
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19EET101 / BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING I YEAR / I SEMESTER

UNIT-II: ANALOG ELECTRONICS

DIODE





TOPIC OUTLINE



- ✓ Introduction
- ✓ Diodes
- ✓ Electrical Properties of Solids
- ✓ Semiconductors
- ✓ PN Junctions
- ✓ Semiconductor Diodes
- ✓ Special-Purpose Diodes
- ✓ Diode Circuits

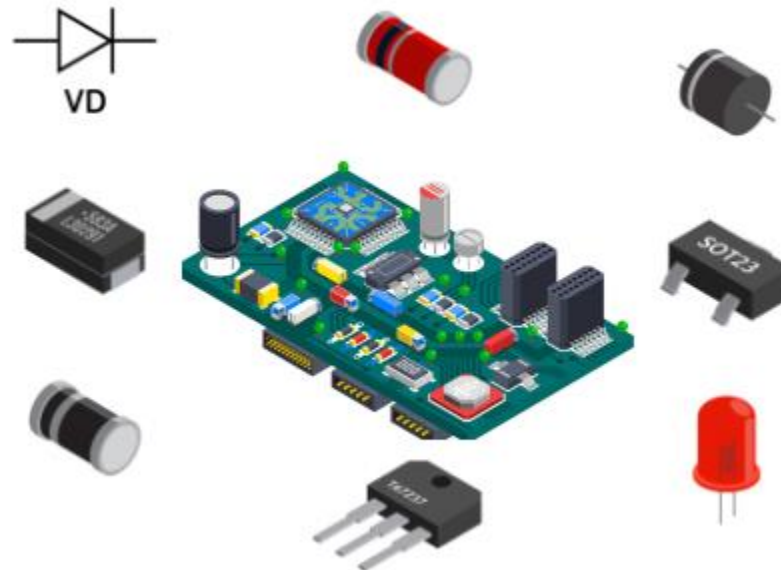




Introduction



A diode is defined as a two-terminal electronic component that only conducts current in one direction (so long as it is operated within a specified voltage level). An ideal diode will have zero resistance in one direction, and infinite resistance in the reverse direction.



Electrical Properties of Solids

- **Conductors**

- e.g. copper or aluminium
- have a cloud of free electrons (at all temperatures above absolute zero). If an electric field is applied electrons will flow causing an electric current

- **Insulators**

- e.g. polythene
- electrons are tightly bound to atoms so few can break free to conduct electricity





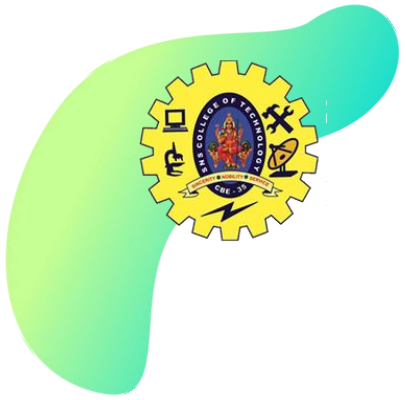
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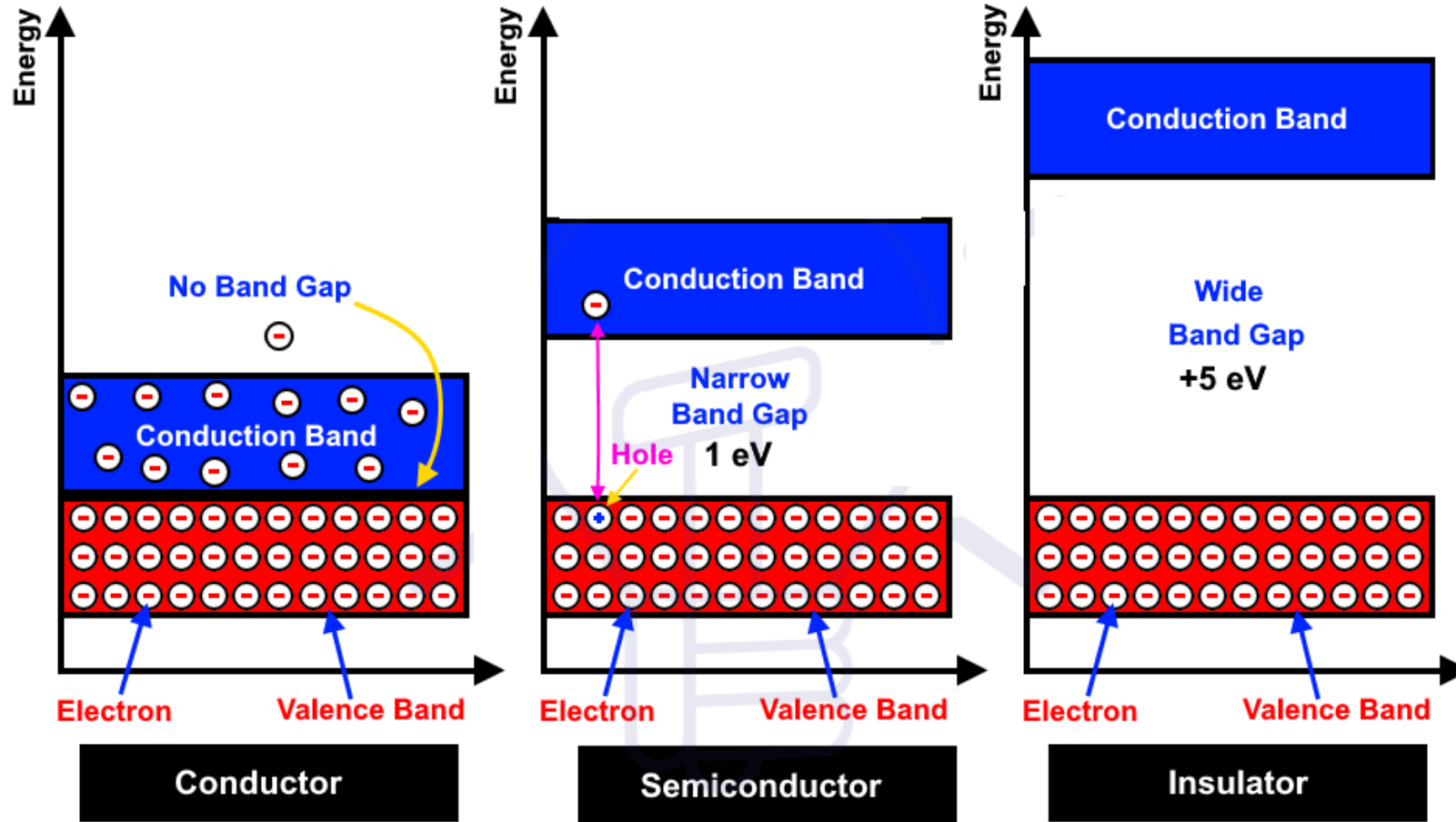
- **Semiconductors**

- e.g. silicon or germanium
- at very low temperatures these have the properties of insulators
- as the material warms up some electrons break free and can move about, and it takes on the properties of a conductor
- however, semiconductors have several properties that make them distinct from conductors and insulators





Contd.,



Semiconductors



- **Pure semiconductors**
 - thermal vibration results in some bonds being broken generating **free electrons** which move about
 - these leave behind **holes** which accept electrons from adjacent atoms and therefore also move about
 - electrons are **negative charge carriers**
 - holes are **positive charge carriers**
- At room temperatures there are few charge carriers
 - *pure semiconductors are poor conductors*
 - this is **intrinsic conduction**



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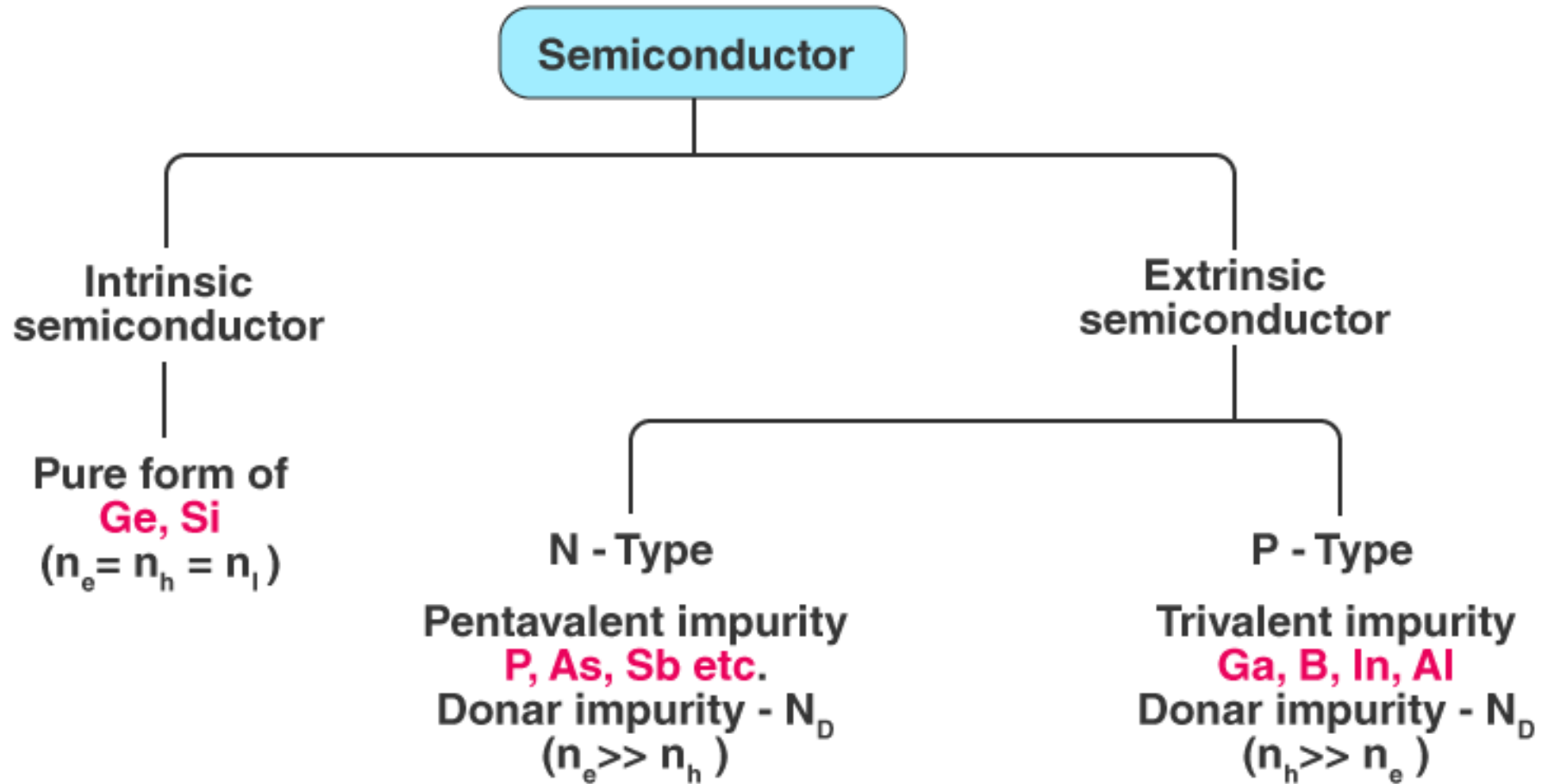


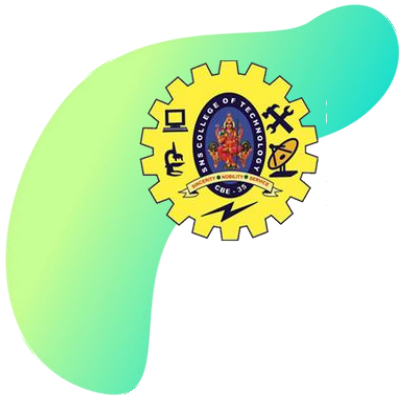
- **Doping**

- the addition of small amounts of impurities drastically affects its properties
- some materials form an excess of *electrons* and produce an ***n-type semiconductor***
- some materials form an excess of *holes* and produce a ***p-type semiconductor***
- both *n-type* and *p-type* materials have much greater conductivity than pure semiconductors
- this is **extrinsic conduction**

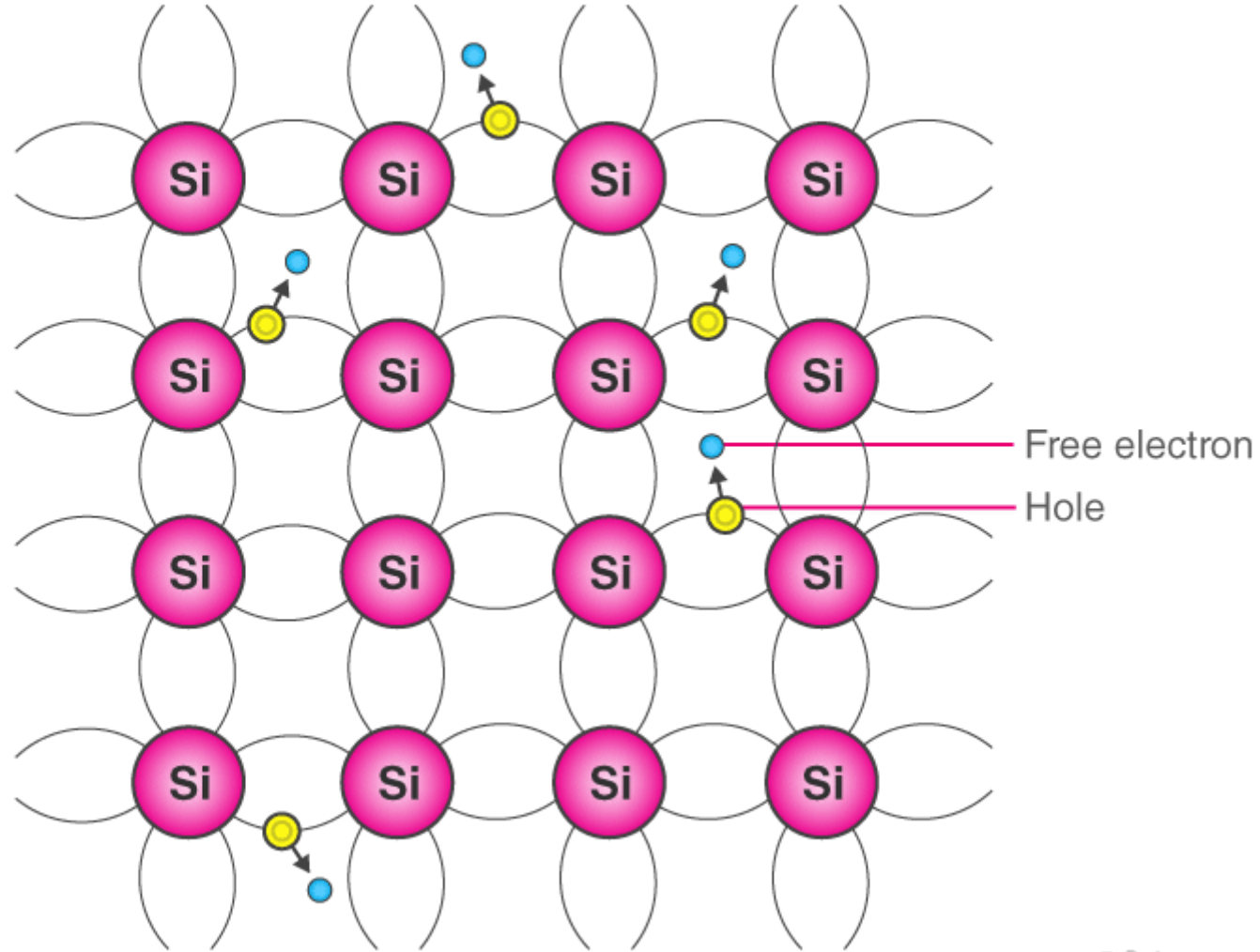


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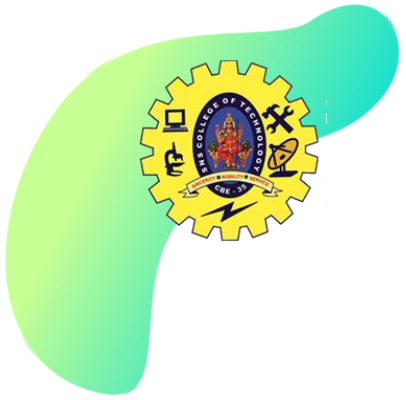


INTRINSIC SEMICONDUCTORS

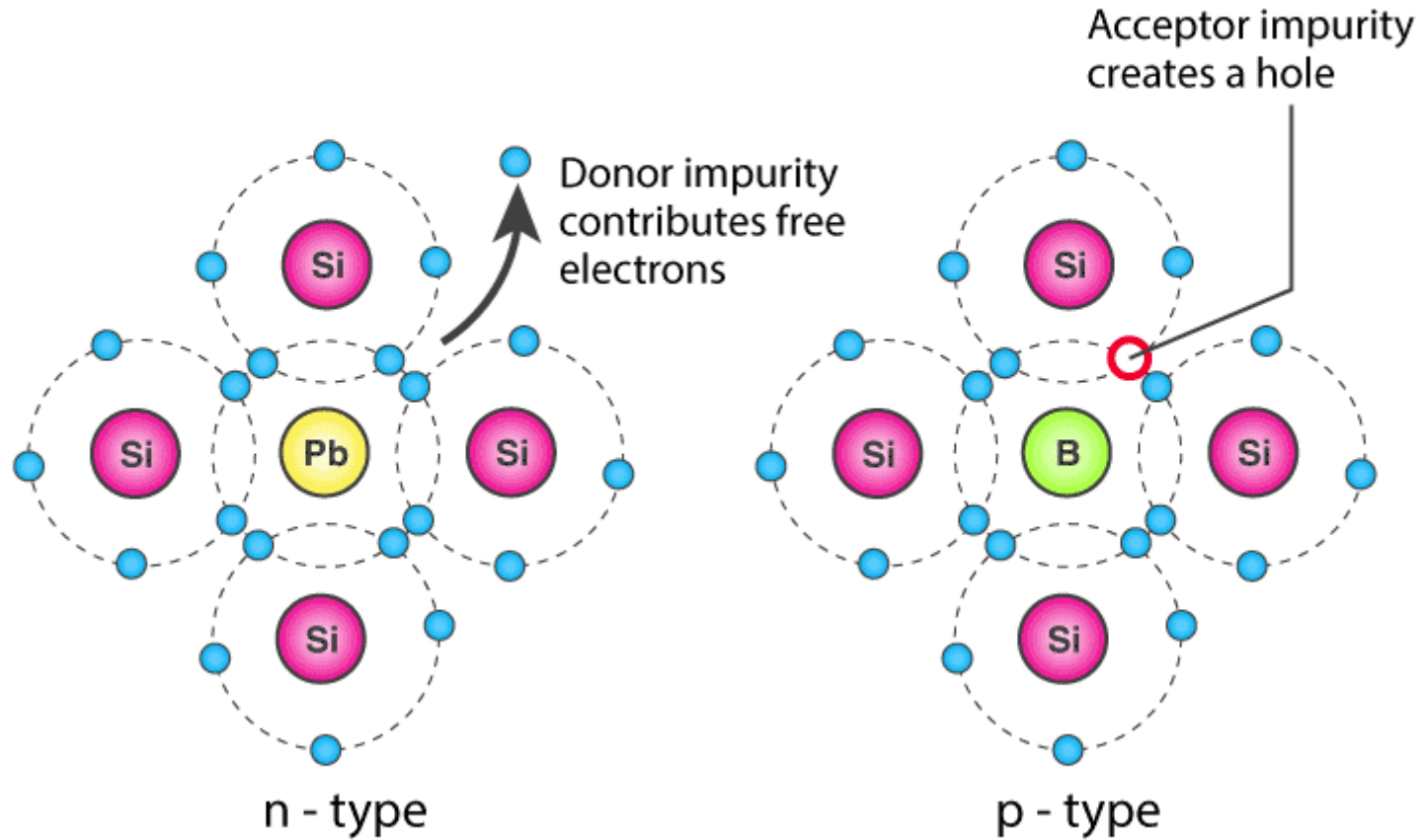


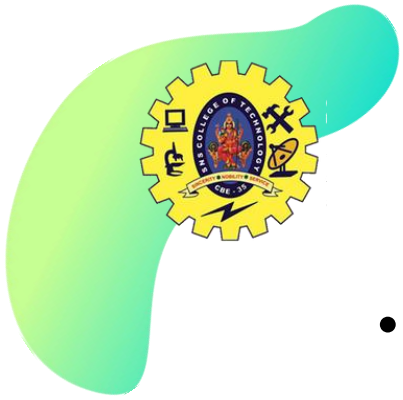
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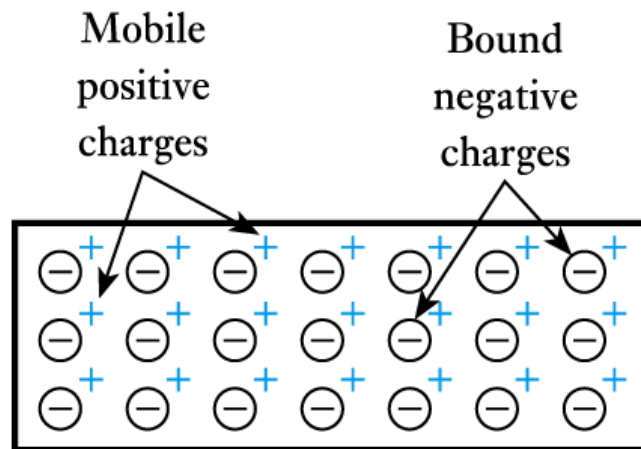
EXTRINSIC SEMICONDUCTORS



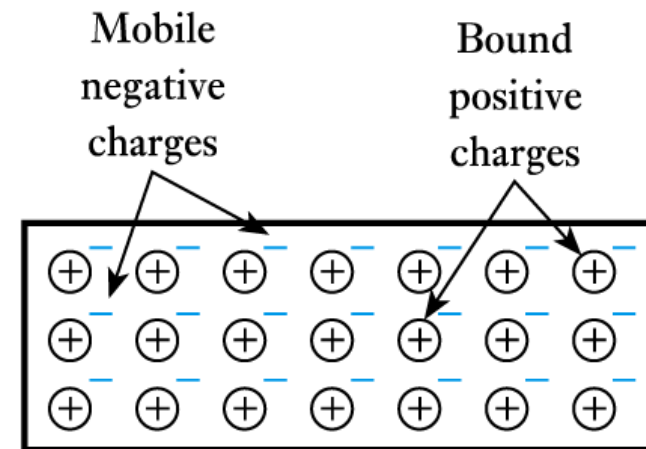


Working principle:

- The dominant charge carriers in a doped semiconductor (e.g. electrons in n -type material) are called **majority charge carriers**. Other type are **minority charge carriers**
- The overall doped material is electrically neutral



(a) p -type semiconductor



(b) n -type semiconductor





pn Junctions



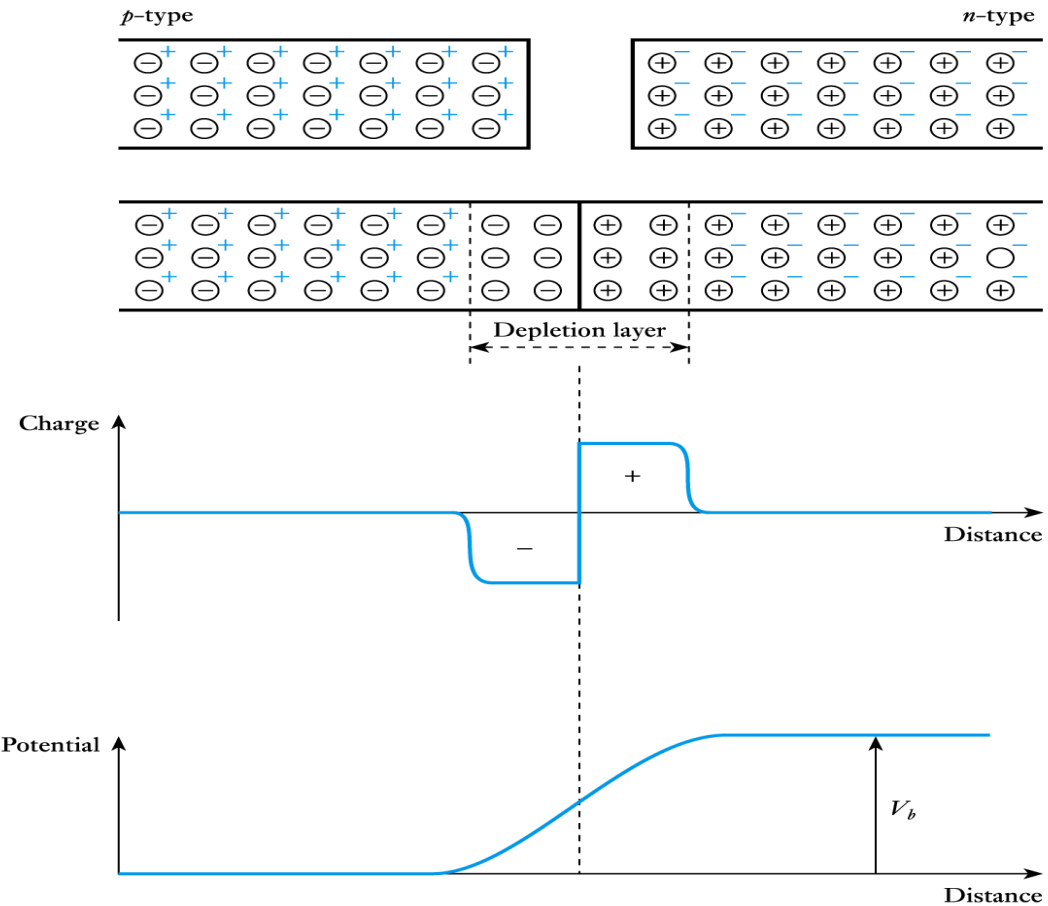
- When p -type and n -type materials are joined this forms a **pn junction**
 - majority charge carriers on each side diffuse across the junction where they combine with (and remove) charge carriers of the opposite polarity
 - hence around the junction there are few free charge carriers and we have a **depletion layer** (also called a **space-charge layer**)





Contd.,

- The diffusion of positive charge in one direction and negative charge in the other produces a charge imbalance – this results in a **potential barrier** across the junction





Working principle:



- **Potential barrier**

- the barrier opposes the flow of *majority* charge carriers and only a small number have enough energy to surmount it
 - this generates a small **diffusion current**
- the barrier encourages the flow of *minority* carriers and any that come close to it will be swept over
 - this generates a small **drift current**
- for an isolated junction these two currents must balance each other and the net current is zero





Working principle:



- **Forward bias**

- if the p -type side is made *positive* with respect to the n -type side the height of the barrier is reduced
- more majority charge carriers have sufficient energy to surmount it
- the diffusion current therefore increases while the drift current remains the same
- there is thus a net current flow across the junction which increases with the applied voltage





Working principle:



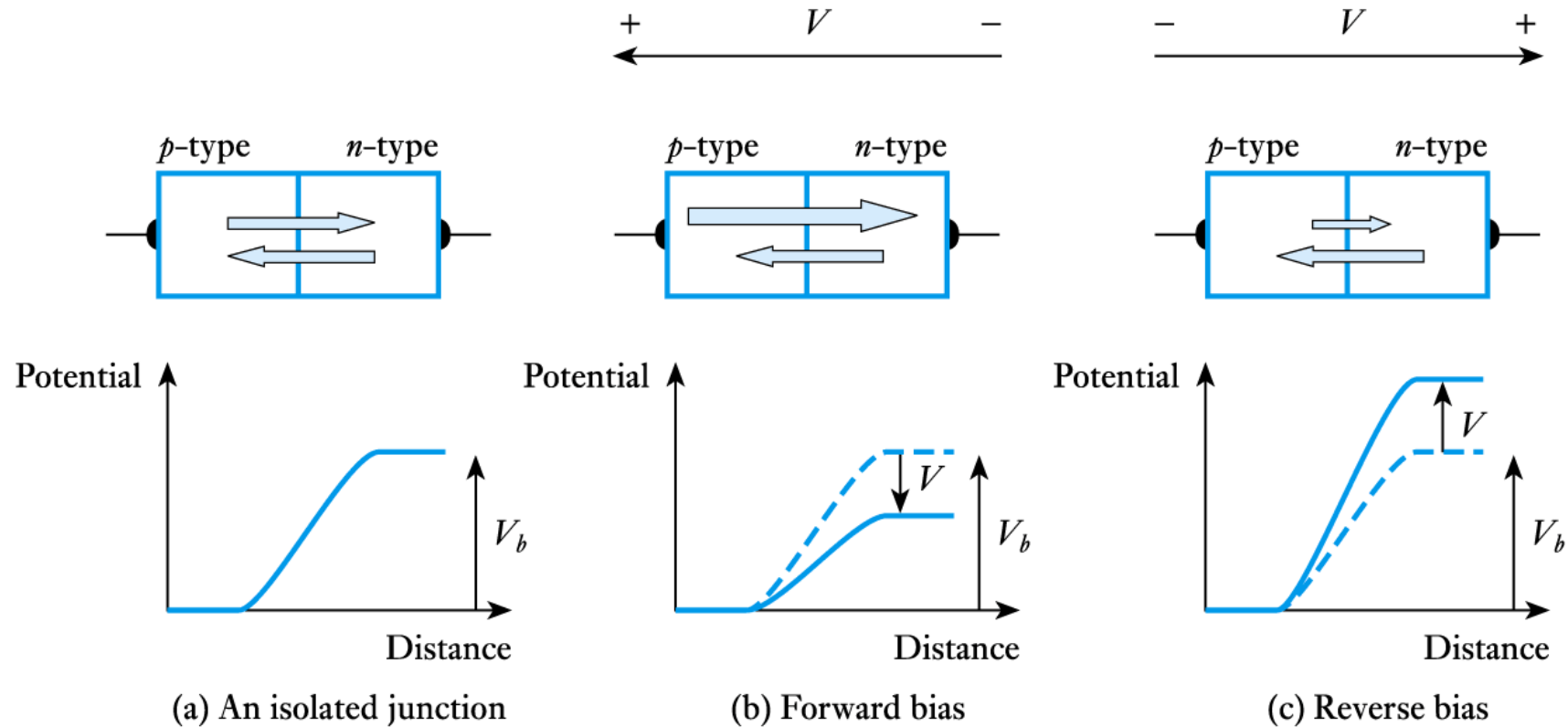
- **Reverse bias**

- if the p -type side is made *negative* with respect to the n -type side the height of the barrier is increased
- the number of majority charge carriers that have sufficient energy to surmount it rapidly decreases
- the diffusion current therefore vanishes while the drift current remains the same
- thus the only current is a small leakage current caused by the (approximately constant) drift current
- the leakage current is usually negligible (a few nA)





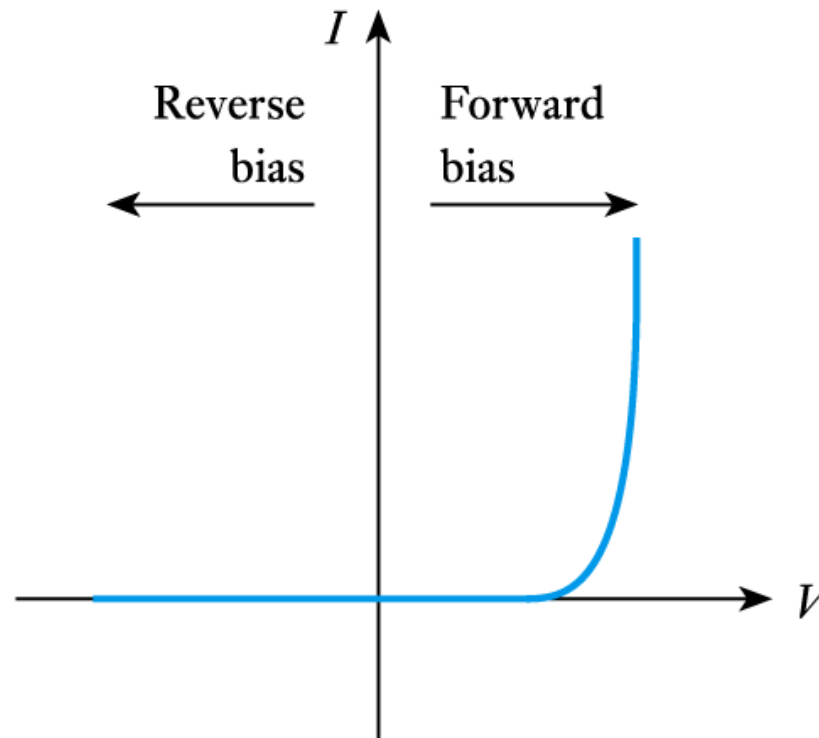
Currents in a *pn* junction





VI Characteristics

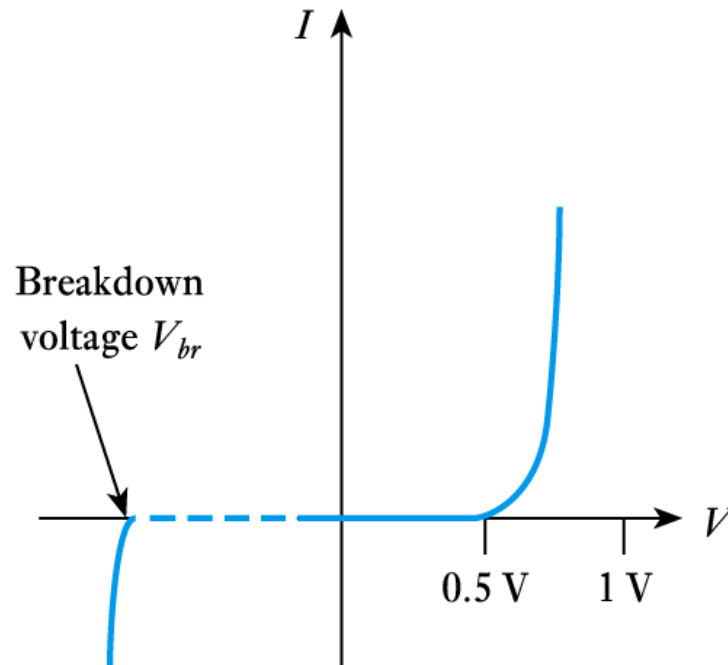
- Forward and reverse currents



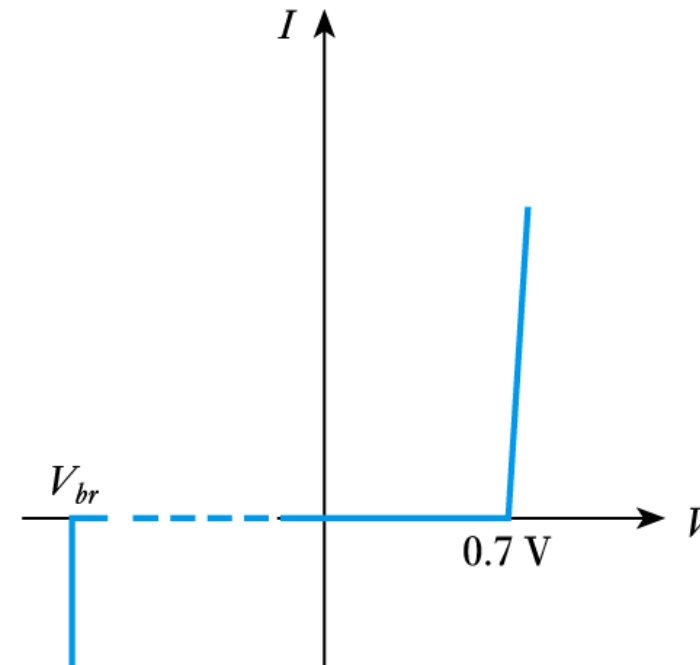


VI Characteristics

- **Turn-on and breakdown voltages** for a silicon



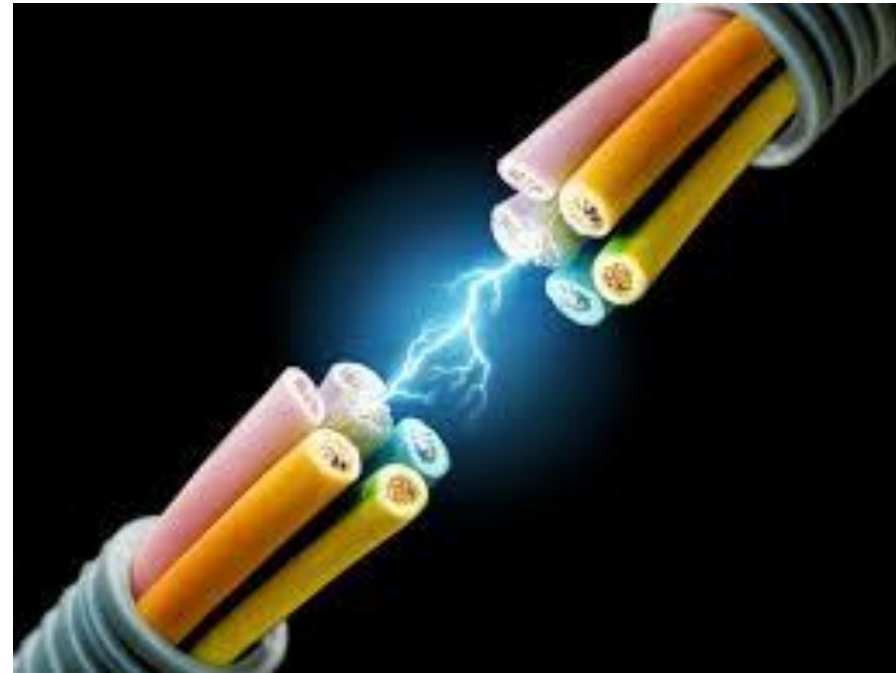
(a) A silicon diode



(b) Straight-line approximation to silicon diode characteristics



RECAP...



...THANK YOU

