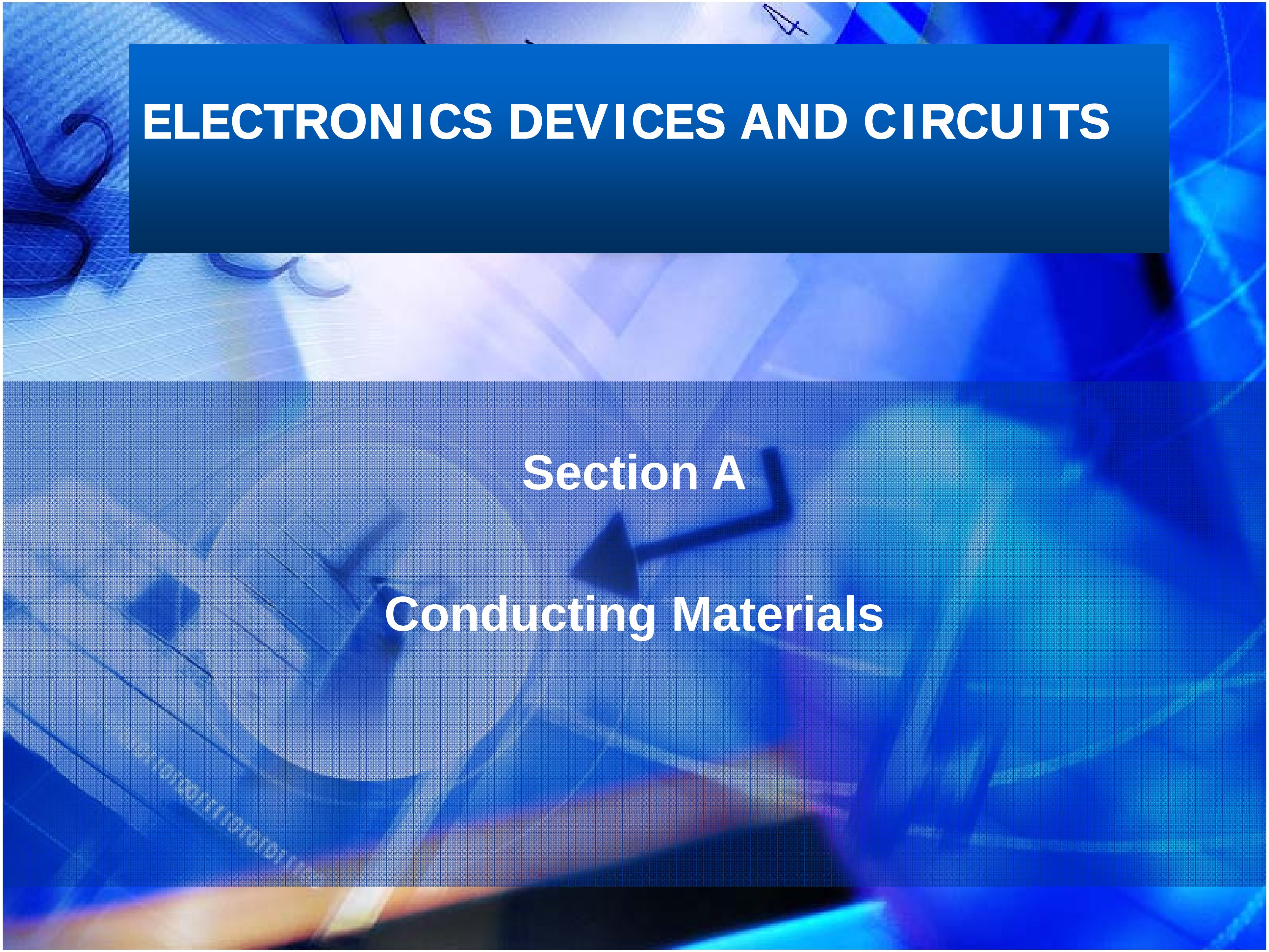


ELECTRONICS DEVICES AND CIRCUITS

Section A

Conducting Materials

OBJECTIVE

MOBILTY AND VARIATION OF MOBILITY WITH TEMPERATURE

❖ Carrier Mobility

Macroscopic understanding

$$\mu = \frac{V_d}{E}$$

In a perfect Crystal

$$\rho = 0$$

$$\sigma \to \infty$$

It is a superconductor

Microscopic understanding? (what the carriers themselves are doing?)

$$\mu = \frac{q\tau}{m^*}$$

$$m_e^* \langle m_h^* \quad in \ general$$

$$m_e^*; n - type$$

$$m_h^*; p - type$$

μ

- A *perfect crystal has a perfect periodicity* and therefore the potential seen by a carrier in a perfect crystal is completely periodic.

- So the *crystal has no resistance to current flow* and behaves as a *superconductor*. The perfect periodic potential does not *impede the movement of the charge carriers*.

μ.....

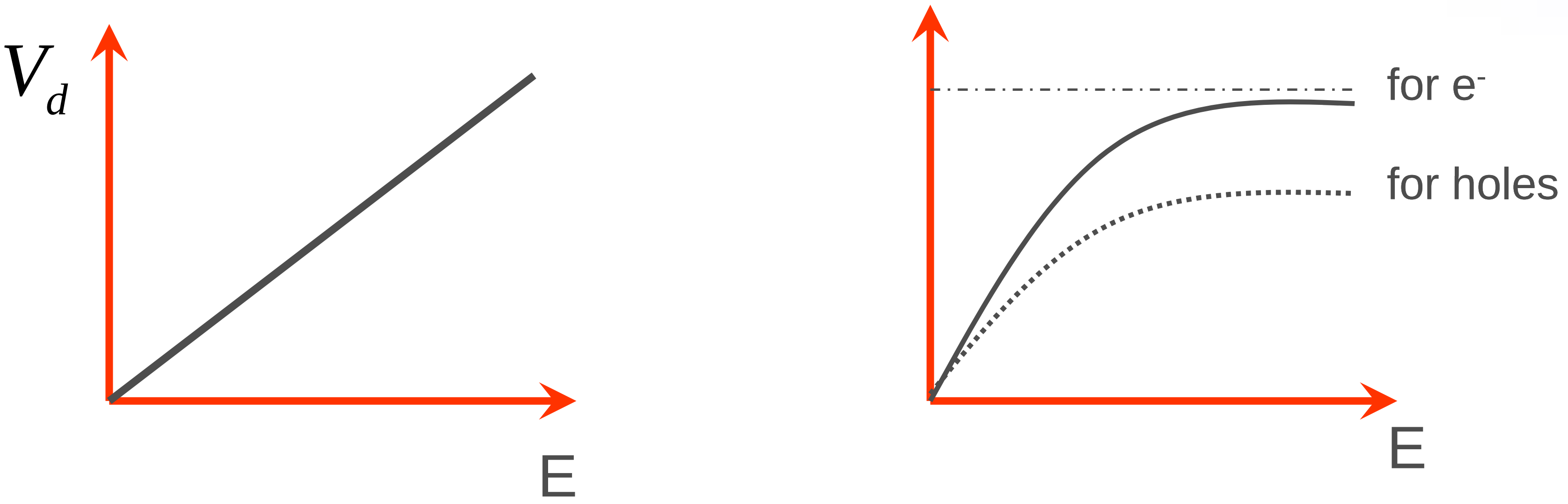
- However, in a real device or specimen, the presence of impurities, interstitials, temperature, etc. creates a resistance to current flow.

- The presence of all these *upsets the periodicity of the potential* seen by a charge carrier.

❖ Saturated Drift Velocities

$$V_d = \mu E$$

So one can make a carrier go as fast as we like just by increasing the electric field!!!



(a) Implication of above eqn.

(b) Saturation drift velocity

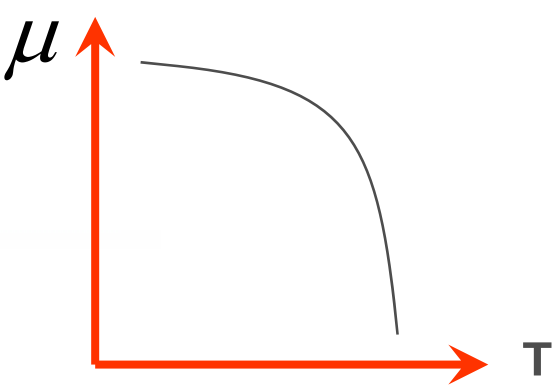
❖ Saturated Drift Velocities

- The equation of $V_d = \mu . E$ does not imply that **V_d** increases linearly with applied field **E.**

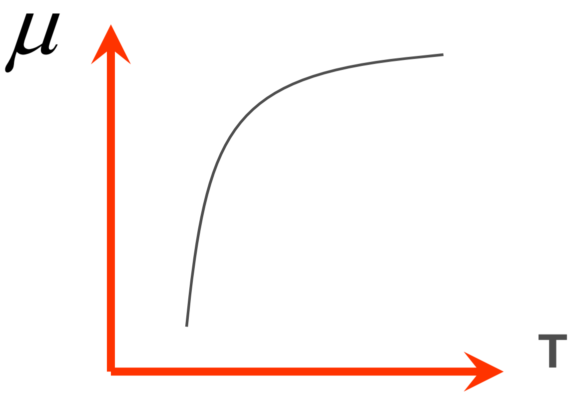
- **V_d** increases linearly for low values of **E** and then it saturates at some value of **V_d** which is close **V_{th}** at higher values of **E**.

- Any further increase in **E** after saturation point does not increase **V_d** instead warms up the crystal.

❖ Mobility variation with temperature



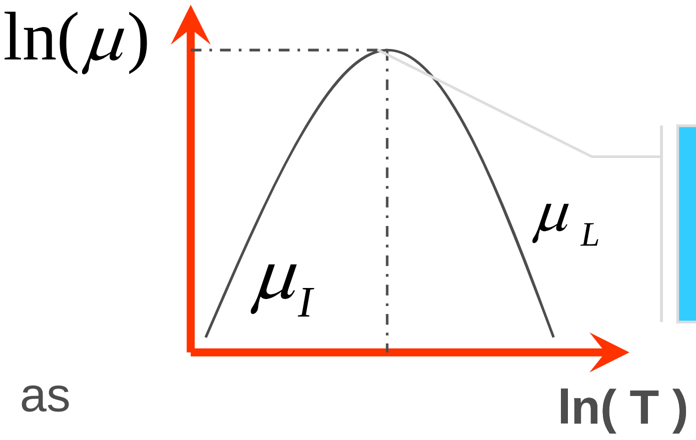
High temperature



Low temperature

$$\frac{1}{\mu_T} = \frac{1}{\mu_L} + \frac{1}{\mu_I}$$

This equation is called as Mattheisen’s rule.



Peak depends on the density of impurities