E-k Diagram and Direct-Indirect band gap

Explained By

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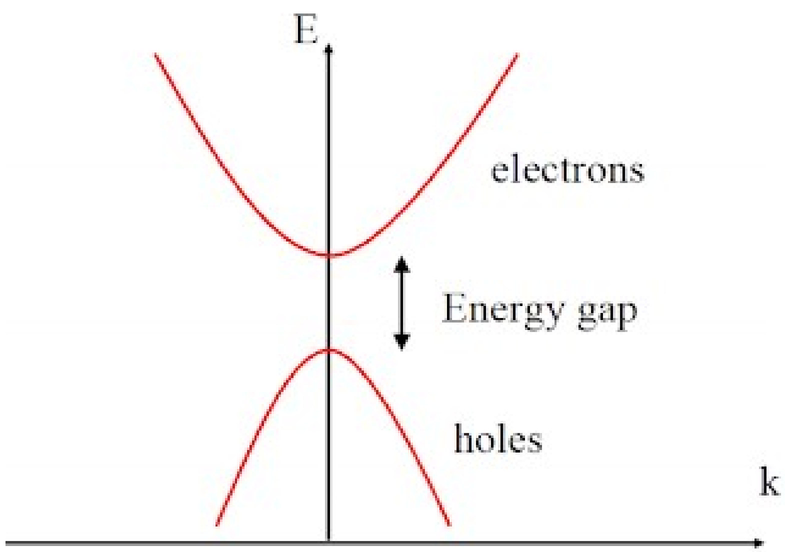
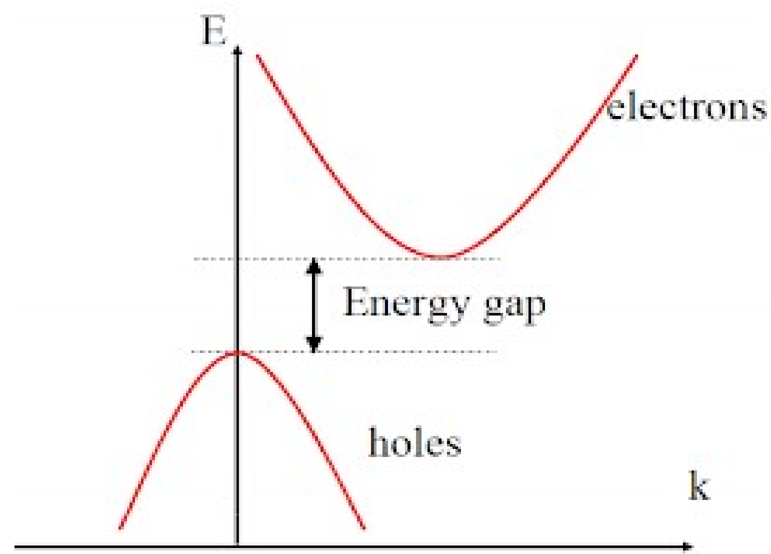
E-k Diagram

1) The conventional band diagram shows the band gap energy only.
2) To know more of electrical and optical properties of semiconductor we need to know E-k diagram.
3) An E-k diagram shows characteristics of a particular semiconductor material.
4) It shows the relationship between the energy and momentum of available states for electrons in the material.
5) k being the momentum and E as the energy. From a mathematical point of view k is the wavevector.
6) the E-k diagram of the semiconductor is obtained by solving Schroedinger's equation.

Significance of E-k Diagram

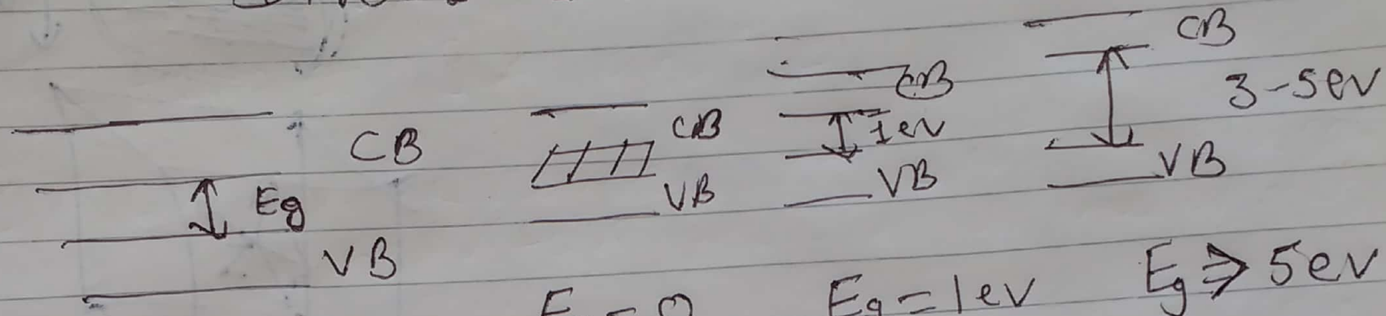
1) No theoretical study, experimentation, and technological application can take place without the E-k diagram.
2) This diagram indicates the band gap (E_G), which is the difference in energy between the top of the valence band and the bottom of the conduction band.
3) This diagram demonstrates Electron (hole) mobility.
4) This diagram explains Electron (hole) effective mass.
5) This diagram indicates how the actual electron states are equally spaced in k-space.
6) This diagram shows direct versus indirect band gap.

No	**Direct Band gap semiconductor**	**Indirect band gap semiconductor**
1	A direct band-gap (DBG) semiconductor is one in which the maximum energy level of the valence band aligns with the minimum energy level of the conduction band with respect to momentum.	A indirect band-gap (DBG) semiconductor is one in which the maximum energy level of the valence band are misaligned with the minimum energy level of the conduction band with respect to momentum.
2	In a DBG semiconductor, a direct recombination takes place with the release of the energy equal to the energy difference between the recombining particles.	Due to a relative difference in the momentum, first, momenta align themselves, a recombination occurs accompanied with the release of energy.
3	The efficiency factor of a DBG semiconductor is higher.	The efficiency factor of a IBG semiconductor is lower.
4	Example of DBG semiconductor material is Gallium Arsenide (GaAs).	Examples of IBG semiconductors are Silicon and Germanium.
5	DBG semiconductors are always preferred over IBG for making optical sources.	The IBG semiconductors cannot be used to manufacture optical sources.

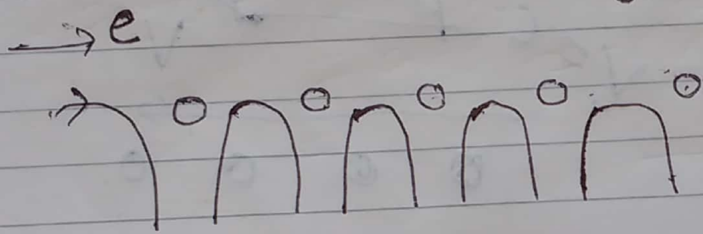
No	Direct Band gap semiconductor	Indirect band gap semiconductor
6	The probability of a radiative recombination is high.	The probability of a radiative recombination is comparatively low.
7		

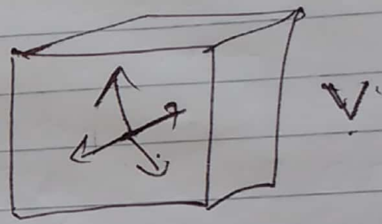
E-k Diagram

Direct - Indirect Band gap



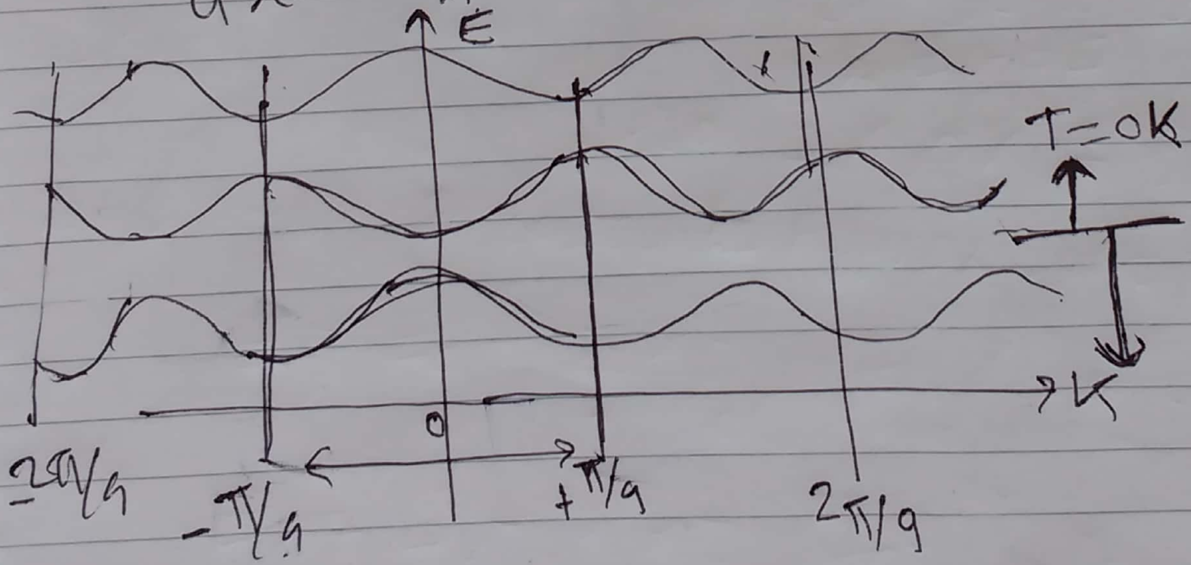
$E_g = 0$ $E_g = 1ev$ $E_g \geq 5ev$



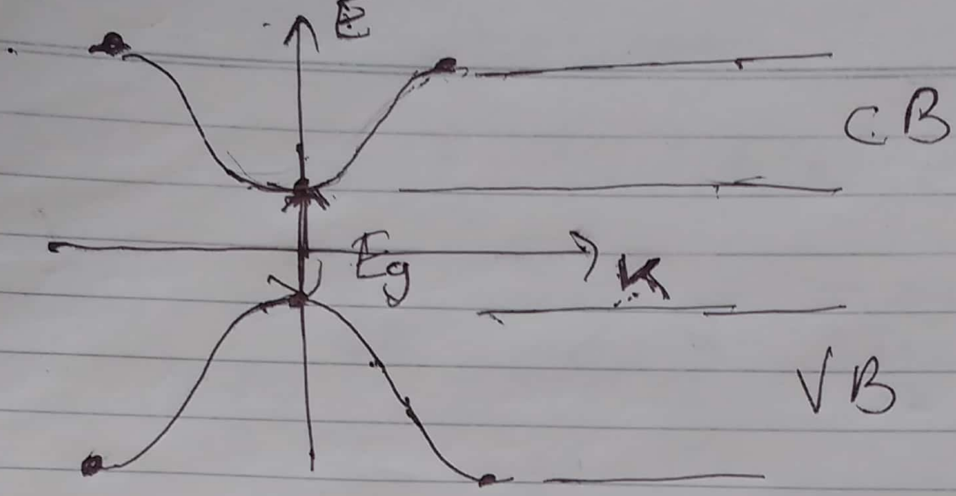


$$\Psi = \underline{u_k}\ \underline{e^{ikx}}$$

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}(E - V) = 0$$



Brillouin Zone



$$K = \frac{2\pi}{\lambda}$$

$$\lambda = \frac{h}{p}$$

$$\Rightarrow p = \frac{h}{\lambda} \times \frac{2\pi}{2\pi}$$

$$\boxed{p = \hbar K}$$