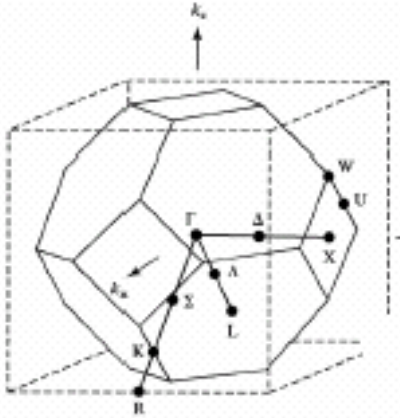
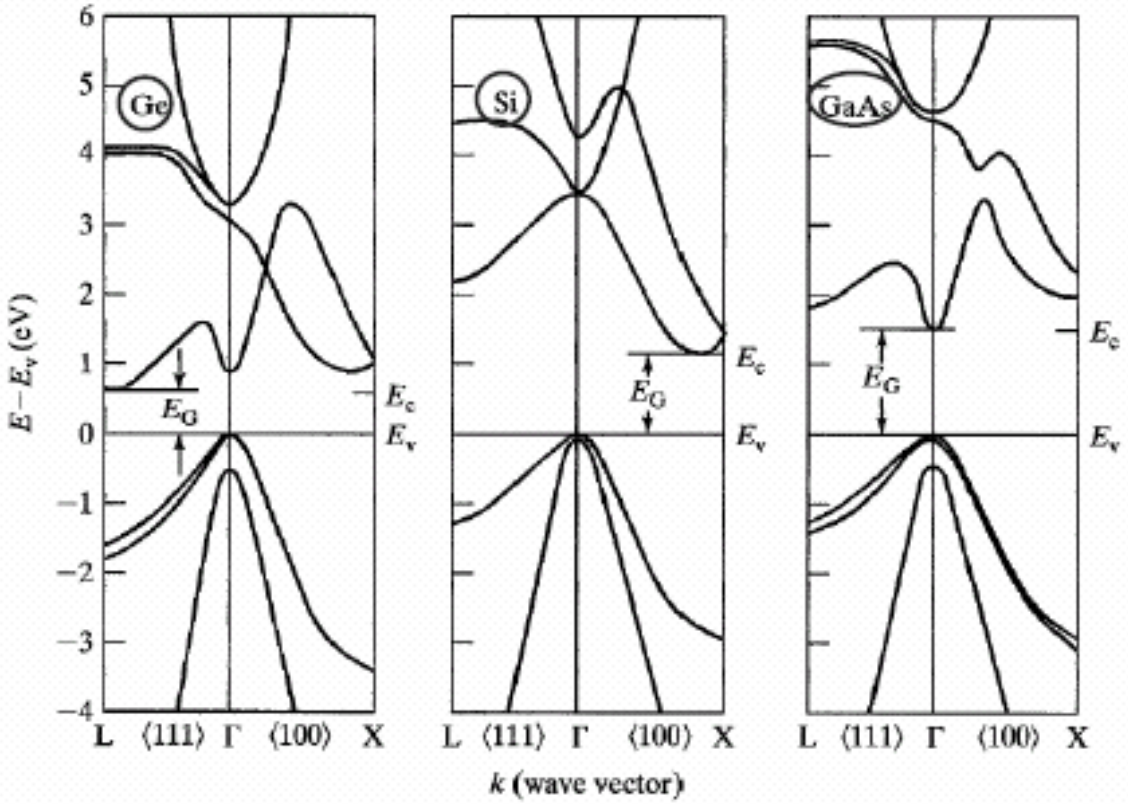
Dispersion (E-k) relation for common semiconductors

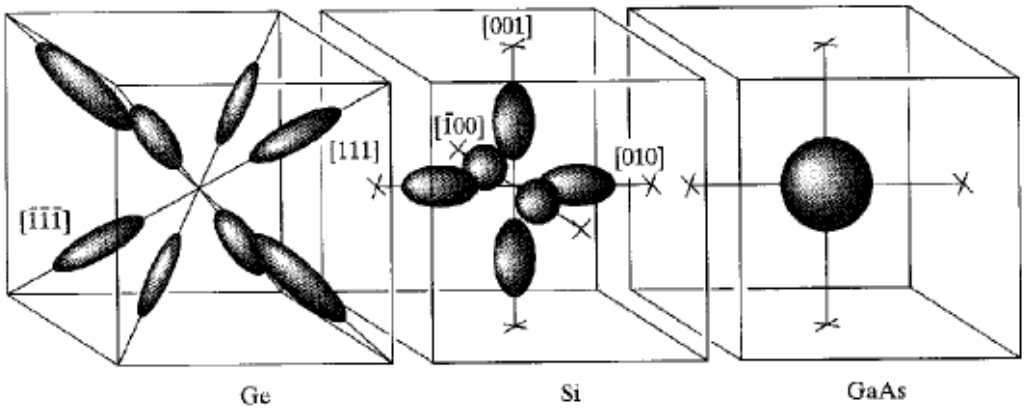


- 3 valence bands (light hole, heavy hole, split-off) valence bands near k=0 is essentially $E \sim k^2$
- Minima may not be at zone center (Ge: 8 L valley, Si: 6 X valley, and GaAs: Γ valley). May transfer from Γ to L to X.



Constant energy surfaces from 4D E-k

Electrons – Ellipsoids or Sphere



Electron effective mass ($/m_0$)

m_t: 0.19

m_l: 0.916

$$E(\mathbf{k}) = E_0 + \frac{\hbar^2}{2m_x^*}(k_x - k_{0,x})^2 + \frac{\hbar^2}{2m_y^*}(k_y - k_{0,y})^2 + \frac{\hbar^2}{2m_z^*}(k_z - k_{0,z})^2$$

Holes – Warped sphere

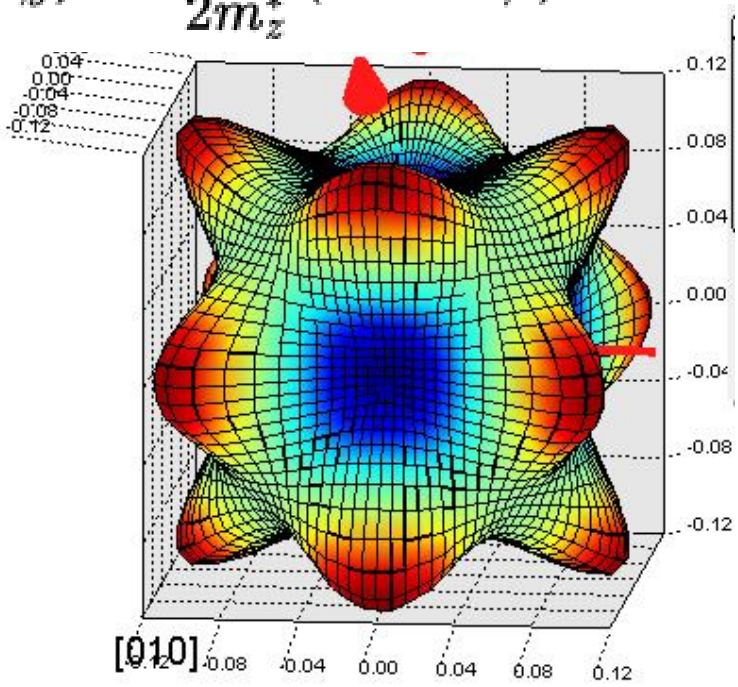
$$E_{\mathrm{hh}} = -Ak^2 - [B^2k^4 + C^2(k_x^2k_y^2 + k_y^2k_z^2 + k_z^2k_x^2)]^{\frac{1}{2}},$$

$$E_{\mathrm{lh}} = -Ak^2 + [B^2k^4 + C^2(k_x^2k_y^2 + k_y^2k_z^2 + k_z^2k_x^2)]^{\frac{1}{2}}.$$

Hole effective mass ($/m_0$)

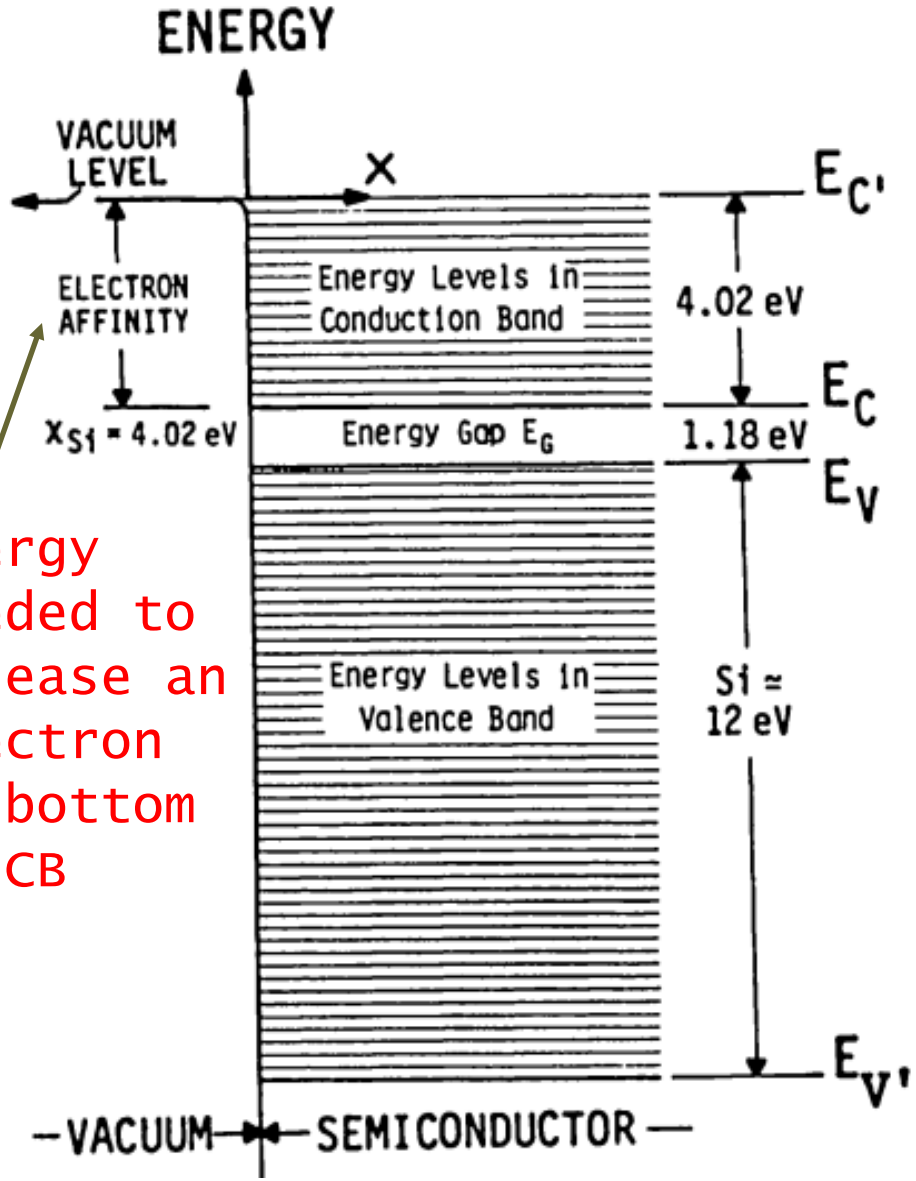
m_{HH}: 0.49

m_{LH}: 0.16



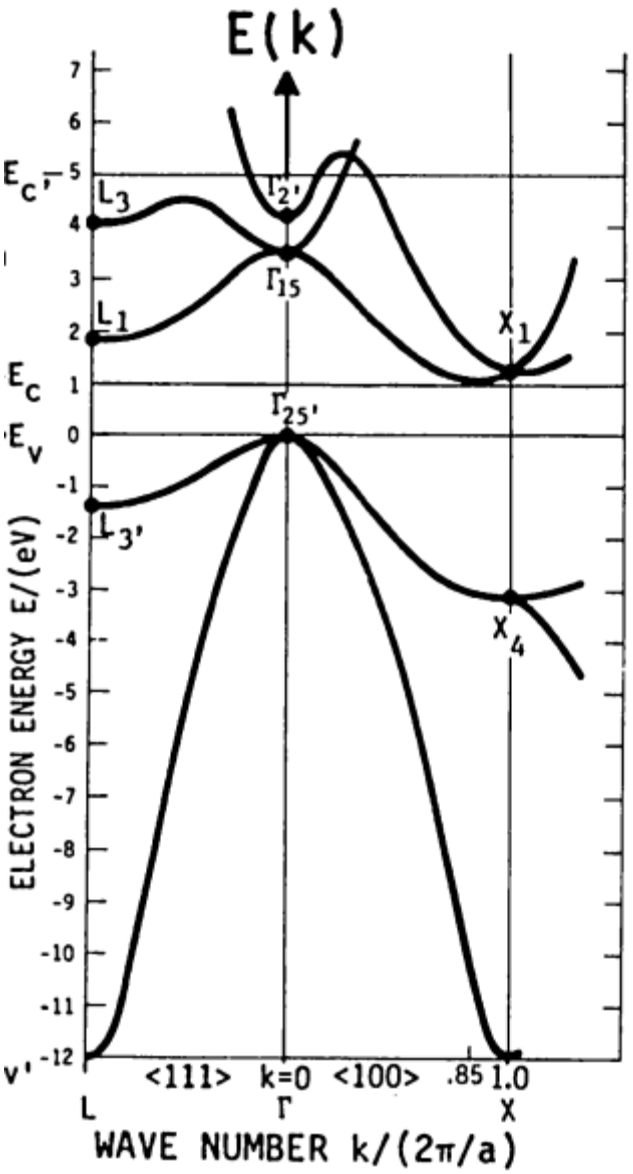
Courtesy: Mastar

Energy band diagram of an electron in Si



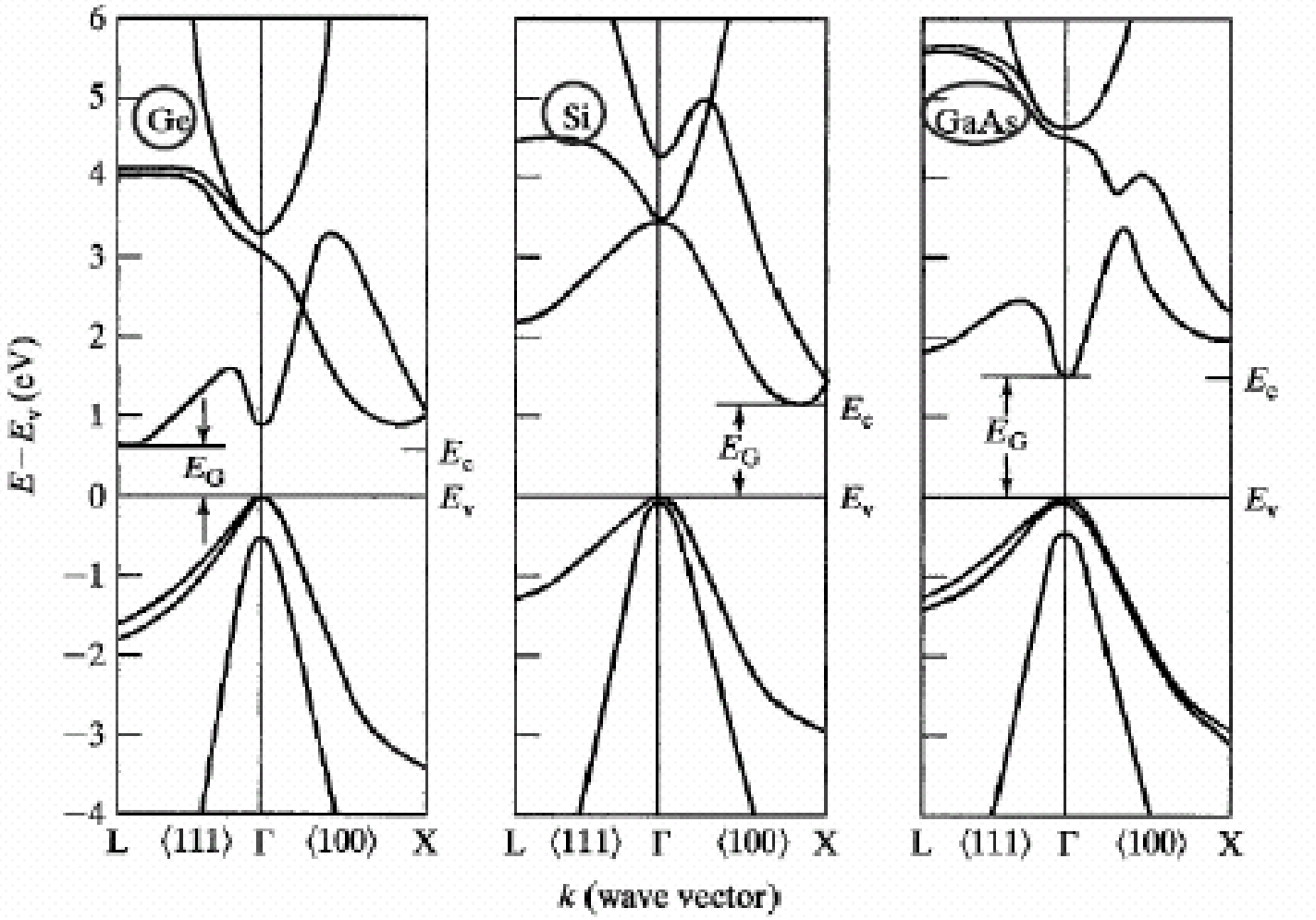
Energy needed to release an electron at bottom of CB

E-x



E-k

Direct and indirect semiconductors



CB minimum and VB maximum lies at same k – Direct (GaAs)
at diff k – Indirect (Si, Ge)