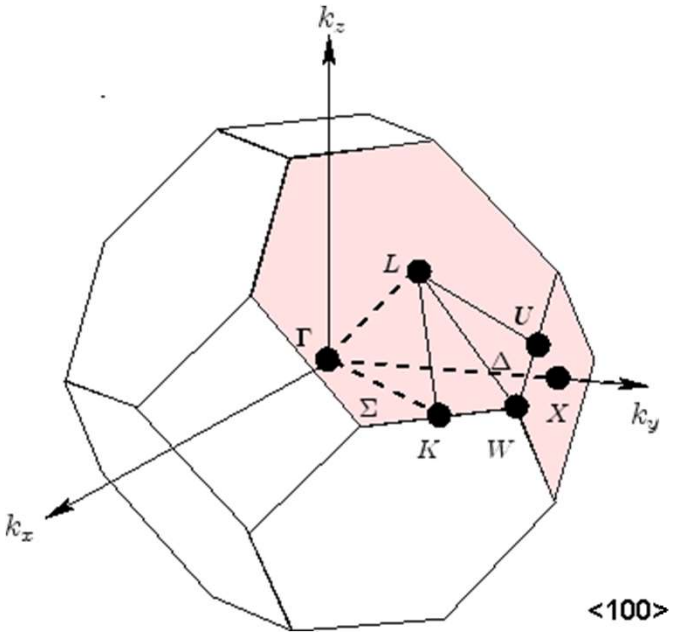
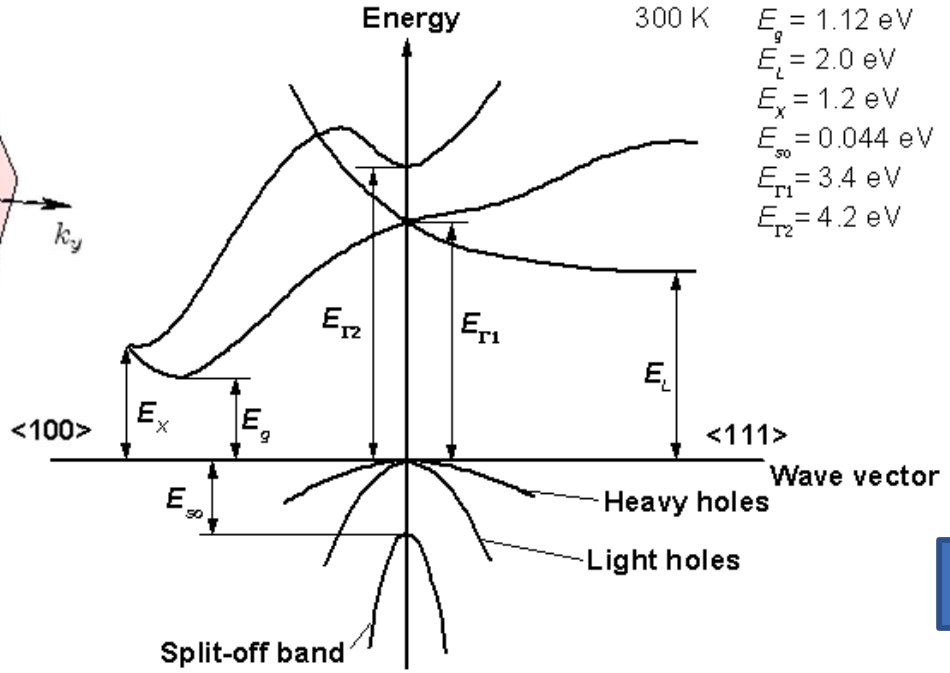
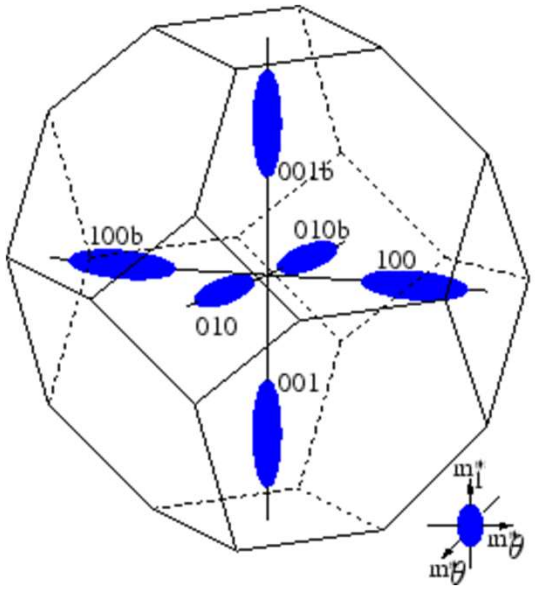
Case study: conduction band of silicon







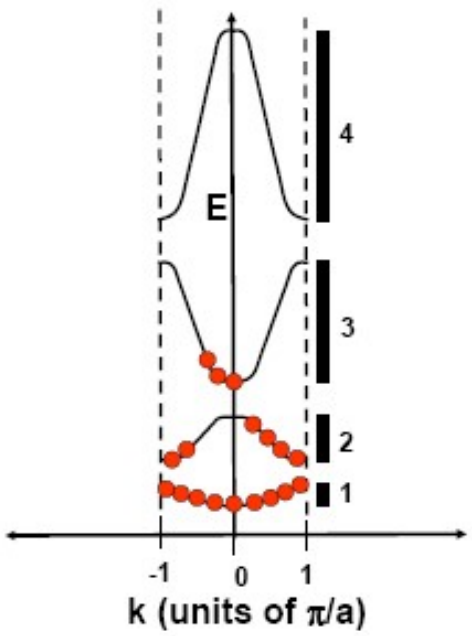
Anisotropy

$$E = E_C + Ak_1^2 + B\left(k_2^2 + k_3^2\right)$$

$$m_{ij}^* = \left(\frac{1}{\hbar^2}\frac{d^2E}{\partial k_i \partial k_j}\right)^{-1}$$

www.ioffe.ru/SVA/NSM/Semicond

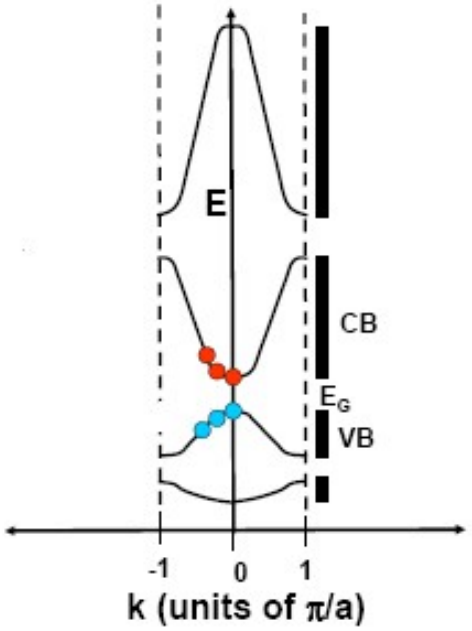
Electrons and holes



$$J_1 = -\frac{e}{V}\sum_{i(all)} v_i = 0, J_4 = 0$$

$$J_3 = -\frac{e}{V}\sum_{i(filled)} v_i$$

$$J_2 = -\frac{e}{V}\sum_{i(filled)} v_i = \frac{e}{V}\sum_{i(empty)} v_i$$



Bands are orthogonal → add contributions from all bands
Only partially-filled bands contribute to current

$$m^* \frac{dv}{dt} = F_{ext} = \frac{d(\hbar k)}{dt} = -e\mathcal{E}$$

$$\Rightarrow \frac{dv}{dt} = \left(\frac{-e}{m^*}\right)\mathcal{E}$$

Concave-down band:

$$m^* < 0 \Rightarrow \frac{dv}{dt} = \left(\frac{-e}{-|m^*|}\right)\mathcal{E} = \left(\frac{e}{|m^*|}\right)\mathcal{E}$$

Holes

Can metals show hole-like conduction?

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Artwork Sources:

1. en.wikipedia.org
2. iue.tuwien.ac.at
3. Souvik Mahapatra (IITB)