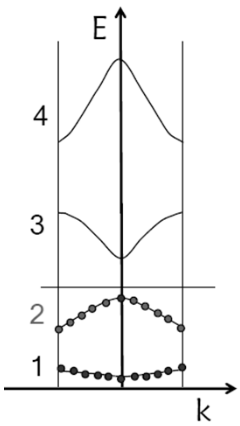
Look back …

- We know what the carriers in semiconductors are. (Electrons, holes)
- We know how they moves inside the semiconductor (effective mass)

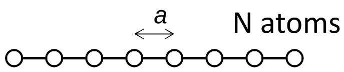
- But we still do not know how many carriers are there.

Density of States



- A single band has totally N states
- Only a fraction of the states are occupied.
- How many states are occupied up to E?
- Or equivalently, how many states are occupied per unit energy?

Density of States in 1D Semiconductors

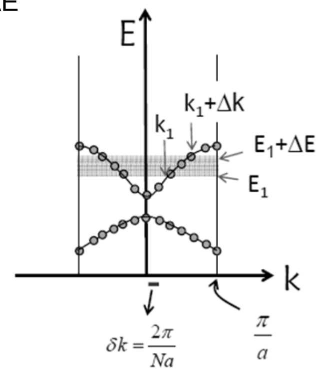


# of States between state E1 & E1+ΔE

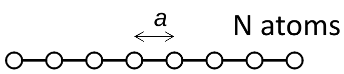
$$= \frac{\Delta k}{\delta k} \times 2 = \frac{\Delta k}{2\pi/Na} \times 2$$

# of states/unit energy at E1

$$= \frac{Na}{\pi}\frac{\Delta k}{\Delta E}$$



1D DOS



$$\text{States/unit energy @ } E = \frac{Na}{\pi}\frac{\Delta k}{\Delta E}$$

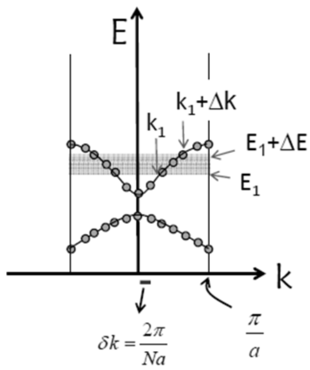
$$E - E_0 = \frac{\hbar^2 k^2}{2m^*} \Rightarrow k = \sqrt{\frac{2m^*(E-E_0)}{\hbar^2}}$$

$$\frac{dk}{dE} = \sqrt{\frac{m^*}{2\hbar^2(E-E_0)}}$$

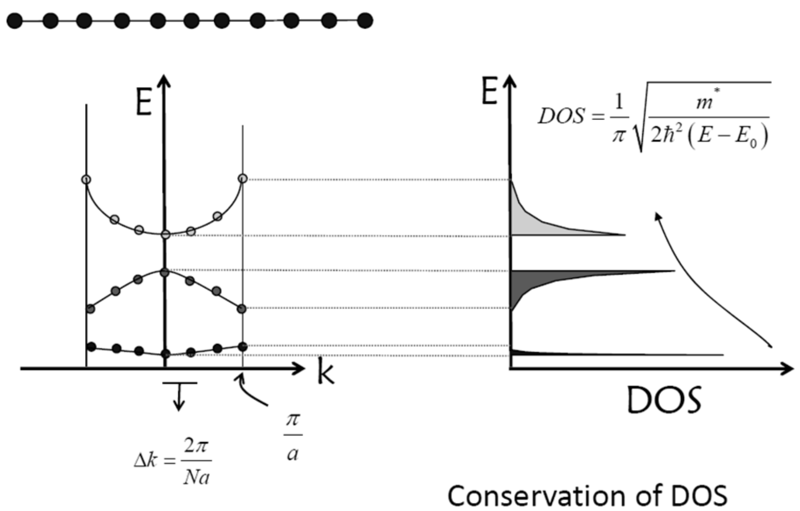
$$\text{States/unit energy @ } E = \frac{L}{\pi}\sqrt{\frac{m^*}{2\hbar^2(E-E_0)}}$$

States/unit energy/unit length @ E

$$\equiv DOS = \frac{1}{\pi}\sqrt{\frac{m^*}{2\hbar^2(E-E_0)}}$$



1D-DOS cont'd



Conservation of DOS

3D Density of States

States between $E_1+\Delta E$ & E_1

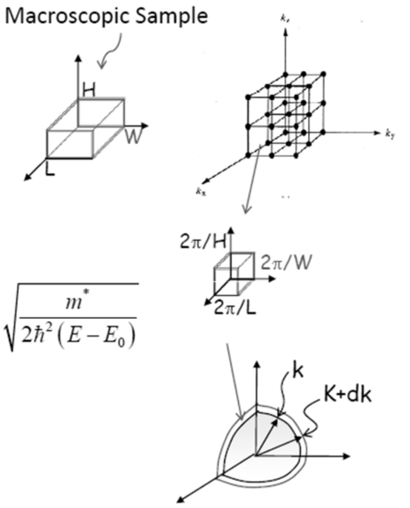
$$= \frac{\frac{4}{3}\pi(k+dk)^3 - \frac{4}{3}\pi k^3}{\frac{2\pi}{L}\frac{2\pi}{W}\frac{2\pi}{H}} = \frac{V}{2\pi^2}k^2\Delta k$$

States/unit energy @ $E \; = \frac{V}{2\pi^2}k^2\frac{\Delta k}{dE}$

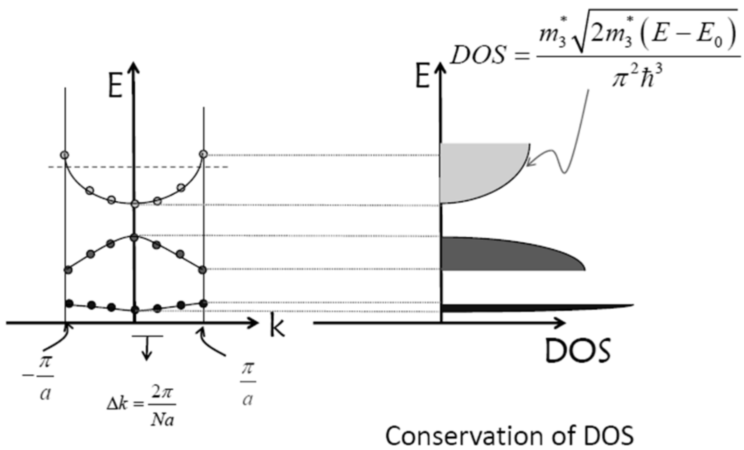
$$E - E_0 = \frac{\hbar^2 k^2}{2m^*} \Rightarrow k = \sqrt{\frac{2m^*(E-E_0)}{\hbar^2}} \Rightarrow \frac{dk}{dE} = \sqrt{\frac{m^*}{2\hbar^2(E-E_0)}}$$

States/unit energy/unit volume @ E_1

$$DOS = \frac{m^*}{2\pi^2\hbar^3}\sqrt{2m^*(E-E_0)}$$

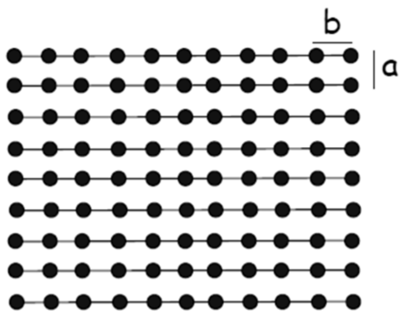


3D-DOS



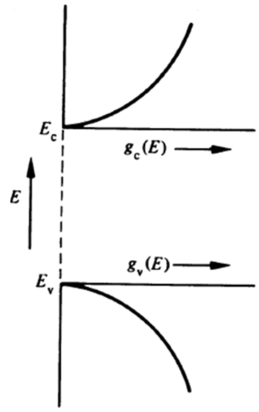
Conservation of DOS

2D DOS?



This is a homework problem.

Density of States for Electrons and Holes



$$g_c(E) = \frac{m_n^* \sqrt{2m_n^*(E - E_c)}}{\pi^2 \hbar^3}, \qquad E \geq E_c$$

$$g_v(E) = \frac{m_p^* \sqrt{2m_p^*(E_v - E)}}{\pi^2 \hbar^3}, \qquad E \leq E_v$$

What does g_c, g_v mean?