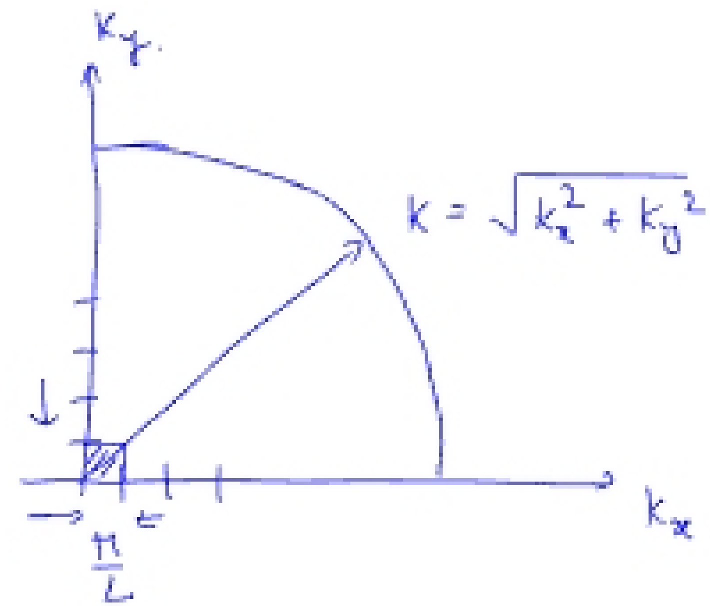
2D Density of States (DOS)

- Assume that the semiconductor is a square with side L. Recall that $\Psi = A\sin(k_x x) + B\cos(k_x x)$

$$k_y = \frac{m\pi}{L}, \quad m = 1, 2, 3 \ldots$$



In a 2-D case, let us assume that the electrons are only allowed to move in the x-y plane due to quantization along the z direction. In that case, the total number of allowed k states in the x and y direction with a magnitude k ($k^2 = k_x^2 + k_y^2$) is given

$$N_{2D} = \left[\frac{\frac{1}{4}\pi k^2}{\left(\frac{\pi}{L}\right)^2}\right] \cdot 2 = 2\left(\frac{L}{2\pi}\right)^2 \pi k^2$$

$$\frac{dN_{2D}}{dk} = 2 \times \left(\frac{L}{2\pi}\right)^2 \cdot 2\pi k$$

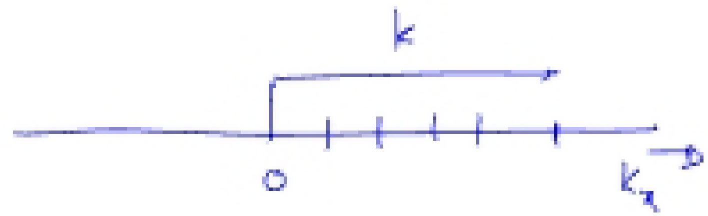
$$\frac{dN_{2D}}{dk} = \frac{dN_{2D}}{dE} \cdot \frac{dE}{dk} : \left(2 \times \left(\frac{L}{2\pi}\right)^2 \cdot 2\pi k\right) \times \frac{m^*}{\hbar^2 k}$$

$$g_{2D} = \frac{1}{A} \cdot \frac{dN_{2D}}{dE} = \frac{1}{L^2}\left(\frac{L^2 m^*}{\pi\hbar^2}\right) = \frac{m^*}{\pi\hbar^2} \propto \frac{4\pi m^*}{h^2}$$

PENNSTATE

1D Density of States (DOS)

- Assume that the semiconductor is a cube with side L. Recall that $\Psi = A\sin(k_x x) + B\cos(k_x x)$



$$N_{1D} = 2 \times \frac{k/2}{(\pi/L)} = 2 \times \left(\frac{L}{2\pi}\right) k$$

$$\frac{dN_{1D}}{dk} = 2 \times \left(\frac{L}{\pi}\right)$$

$$\frac{dN_{1D}}{dE} = \frac{dN_{1D}}{dk} \cdot \frac{dk}{dE} = \left[2 \times \frac{L}{2\pi}\right] \cdot \frac{m^*}{\hbar^2 k} = \frac{L m^*}{\pi \hbar^2 k}$$

$$E = \frac{\hbar^2 k^2}{2m^*}$$

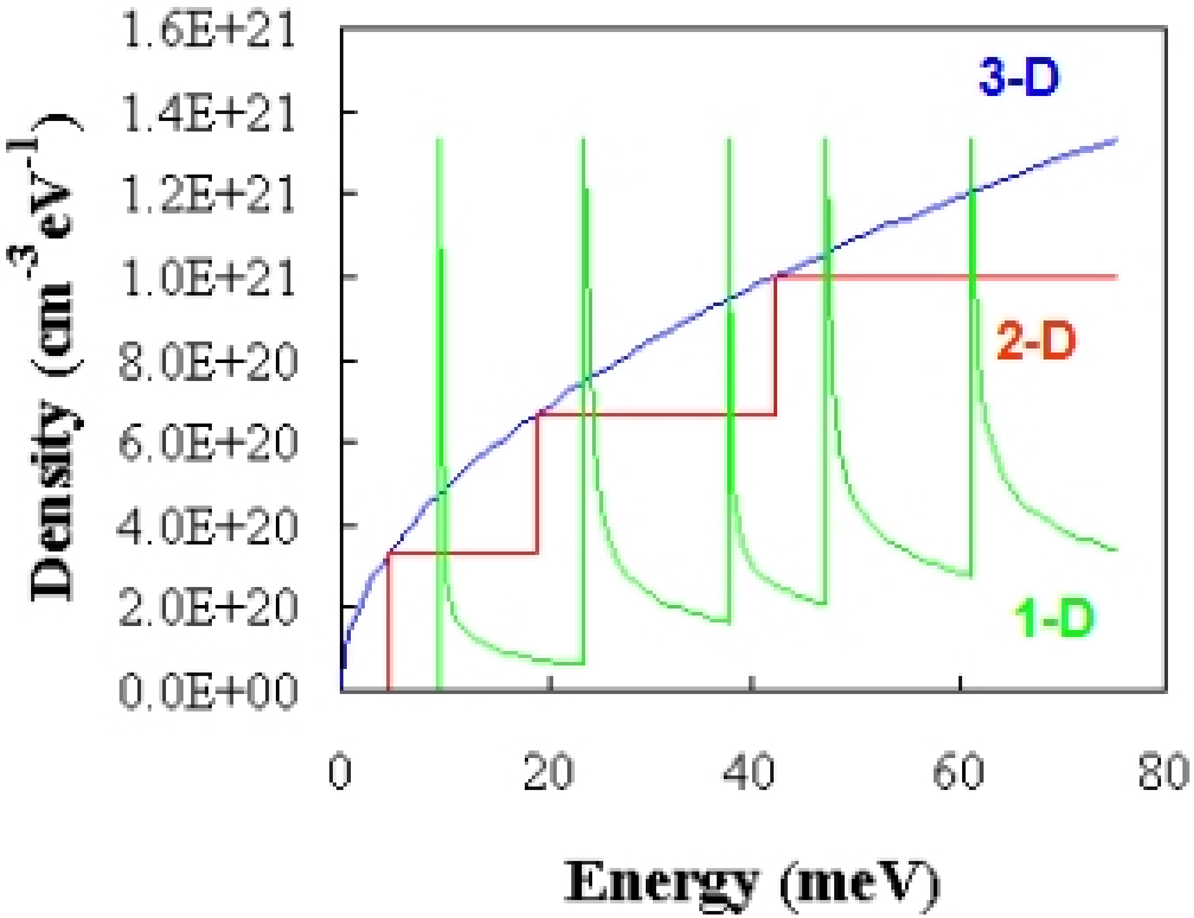
$$g_{1D} = \frac{1}{L}\frac{dN_{1D}}{dE} = \frac{m^*}{\pi \hbar^2 k} = \sqrt{\frac{m^*}{2\pi\hbar^2}} \cdot \frac{1}{\sqrt{E}}$$

$g_{3D} \sim \sqrt{E}$

g_{2D} – Constant

$g_{1D} \sim \frac{1}{\sqrt{E}}$

One and Two dimensional DOS



Density of states per unit volume and energy for a 3-D semiconductor (blue curve), a 10nm quantum well with infinite barriers (red curve) and a 10 nm by 10 nm quantum wire with infinite barriers (green curve). $m^*/m0 = 0.8$