Fundamentals of Nanoelectronics

ECE495 - Session 24, Oct 23, 2009

Graphene Density of States

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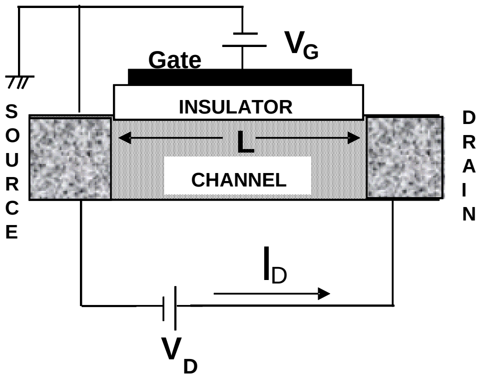
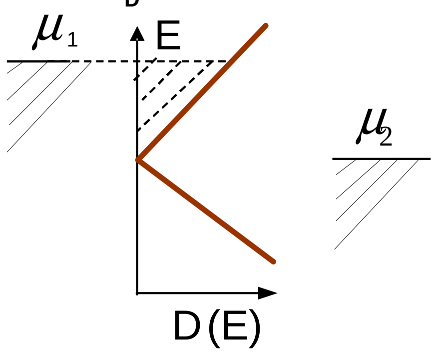


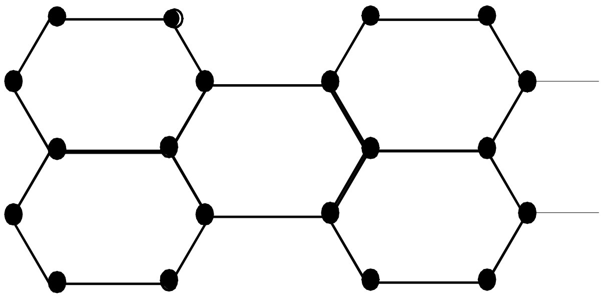
Review

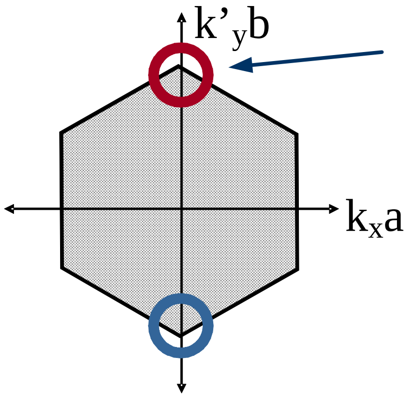
$$h(\vec{k}) = \sum_m [H_{nm}] e^{i\vec{k}(\vec{d}_m - \vec{d}_n)}$$

$$D(E) = \sum_{\vec{k}} \delta(E - \varepsilon(\vec{k}))$$

$$M(E) = \sum_{\vec{k}} \delta(E - \varepsilon(\vec{k})) \frac{\pi \hbar v_z}{L}$$







$$\varepsilon = \varepsilon_0 \pm at \sqrt{k_x^2 + \underbrace{(k_y' - \frac{2\pi}{3b})}_{k_y}{}^2} \xrightarrow{\varepsilon_0 = 0} \varepsilon$$

$$= \pm atk$$

Large Device

$$D(E) = \sum_{\vec{k}} \delta(E - \varepsilon(\vec{k})) = \frac{WL}{4\pi^2}\int_0^{2\pi} d\theta \int_0^{\infty} \delta\left(E - \varepsilon(\vec{k})\right) kdk$$

$$= \frac{WL}{2\pi}\int_0^{\infty} \delta\left(E - \varepsilon(\vec{k})\right) kdk = \frac{WL}{2\pi}\int_0^{\infty} \delta\left(E - \varepsilon(\vec{k})\right) kdk$$

$$= \frac{WL}{2\pi}\int_0^{\infty} \delta\left(E - \varepsilon(\vec{k})\right) k\frac{d\varepsilon}{at} = \frac{WL}{2\pi at}\int_0^{\infty} \frac{\varepsilon}{at} d\varepsilon \delta\left(E - \varepsilon(\vec{k})\right) = \frac{WL|E|}{2\pi a^2 t^2}$$

Small Devices in y direction and Big in x direction

$$D(E) = \sum_{\vec{k_x}}\sum_{\vec{k_y}} \delta\left(E - \varepsilon(\vec{k})\right) = \sum_{\underbrace{k_y}_{v\frac{2\pi}{L}}} \frac{L}{2\pi}\int dk_x\, \delta\left(E - at\sqrt{k_x^2 + k_y^2}\right) = \frac{L}{2\pi}\sum_{v}\int dk_x\, \delta\left(E - \varepsilon(\vec{k})\right)$$

Where $k_v = v\frac{2\pi}{W}$

$$\varepsilon = \sqrt{a^2t^2(k_x^2 + k_y^2)} = \sqrt{a^2t^2k_x^2 + \varepsilon_v^2}$$

$$d\varepsilon = \frac{2a^2t^2k_x}{2\varepsilon}dk_x \Rightarrow atk_x = \sqrt{\varepsilon^2 - \varepsilon_v^2}$$

$$D(E) = \frac{L}{2\pi}\sum_v \int d\,\varepsilon\, \delta(E - \varepsilon)\frac{\varepsilon}{a^2t^2k_x} = \frac{L}{2\pi}\sum_v \frac{E}{at\sqrt{E^2 - \varepsilon_v^2}} = \frac{L}{2\pi at}\sum_v \frac{E}{\sqrt{E^2 - \varepsilon_v^2}}$$

Where $\varepsilon_v = at\frac{2\pi}{W}v$