ECE 656: Fall 2009
Lecture 24 Homework
(Revised 10/28/09)

1) In Lecture 24, we derived a general expression for the electron-phonon scattering rate as:

$$\frac{1}{\tau} = \frac{1}{4\pi^2} \int_{\beta_{\min}}^{\beta_{\max}} C_\beta \left(N_\omega + \frac{1}{2} \mp \frac{1}{2} \right) \beta^2 \, d\beta$$

Repeat the derivation and derive the corresponding expression for two-dimensional electrons. You may assume parabolic energy bands and that C_β for 2D electrons is given.

L24

nothing changes for momentum / energy conservation

$$S(\vec{p},\vec{p}\,') = \frac{2\pi}{\hbar}|K_\beta|^2 \frac{1}{\hbar v \beta}\, \delta\left(\pm\cos\Theta + \frac{\hbar\beta}{2p} \mp \frac{\omega}{v\beta}\right) \qquad (1)$$

the phonon amplitude: $M \rightarrow \rho\Omega$

assume a film with thickness t $\Omega = tA$

$M \rightarrow \rho t A$ $\rho t = \rho_s$ mass density / area

$$|A|^2 \rightarrow \frac{\hbar}{2\rho_s A \omega}\left(N_\omega + \frac{1}{2} \mp \frac{1}{2}\right)$$

$$S(\vec{p},\vec{p}\,') = \frac{1}{A} C_\beta \left(N_\omega + \frac{1}{2} \mp \frac{1}{2}\right) \delta\left(\pm\cos\Theta + \frac{\hbar\beta}{2p} \mp \frac{\omega}{N\beta}\right) \qquad (2)$$

$$C_\beta = \frac{\pi}{\hbar \rho_s v \omega \beta} |K_\beta|^2$$

scattering rate $\frac{1}{\tau} = \sum_{\vec{p}\,',\uparrow}' S(\vec{p},\vec{p}\,')$

$$\frac{1}{T} = \frac{A}{(2\pi)^2} \int_0^{\infty} \beta\, d\beta \int_0^{2\pi} S(\vec{p}, \vec{\beta}')\, d\theta$$

$$= \frac{1}{4\pi^2} \int_0^{\infty} C_\beta \left(N_\omega + \frac{1}{2} \mp \frac{1}{2}\right) \beta\, d\beta \int_0^{2\pi} \delta\left(\pm \cos\theta + \frac{\hbar\beta}{2p} \mp \frac{\omega}{v\beta}\right) d\theta$$

working this out is left as an exercise for the student!

2)