ECE 656 Homework (Week 14)

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1) Monte Carlo simulations of high-field transport in bulk silicon with an electric field of 100,000 V/cm show the following results for the average velocity and kinetic energy:

$\upsilon_d = \langle \upsilon \rangle = 1.04 \times 10^7$ cm/s

$u = \langle KE \rangle = 0.364$ eV

Estimate the average momentum relaxation time, $\langle \tau_m \rangle$ and energy relaxation time, $\langle \tau_E \rangle$.

2) In this problem, we will try to estimate the average kinetic energy and the energy relaxation time of electrons in bulk, <111> oriented Si under an electric field of 20 kV/cm. Assume that the velocity is saturated at 10^7 cm/s and that the conductivity effective mass is $m_C^* = 0.26 m_0$. You should also assume that the dominant scattering mechanism is optical (or intervalley) phonon scattering with $\hbar\omega_0 = 0.063$ eV and that momentum relaxation is dominated by ADP scattering with $\mu_n = \mu_{n0}\sqrt{T_L/T_e}$, where $\mu_{n0} = 1400$ cm²/V-s, $T_L = 300$ K is the lattice temperature and T_e is the electron temperature.

HINT: Some of this information may be useful in solving this problem.

2a) Determine the electron temperature.

2b) Develop an expression for the energy relaxation time of an average electron in terms of the momentum relaxation time (you will not be able to get a numerical answer at this point).

2c) Compare (quantitatively) the energy relaxation time to the momentum relaxation time for this example.