Nanoscale Devices & Systems (ECE212A) – ECE MS Comp Exam, Fall 2013

Closed book. Calculator allowed.

1. Consider a semiconductor material in which the electronic band structure of the conduction band is given by the following relationship:

$$E(\mathbf{k}) = \sqrt{E_0^2 + \Delta^2 k^2}$$

   a. Compute the electronic density of states for the conduction band of this material in three dimensions, as a function of E_0 and Δ.
   b. Compute the electronic density of states for the conduction band of this material in two dimensions, assuming that confinement via infinite potential energy barriers in the third dimension yields a single confined state with energy E_1. Note that E_1 is the actual energy of the confined state, so the energy increase due to quantum confinement is $E_1–E_0$. Express your result as a function of (as needed) E, E_1, E_0 and Δ.
   c. Compute the electronic density of states for the conduction band of this material in one dimension, assuming that confinement via infinite potential energy barriers in the third dimension yields a single confined state with energy E_{11}. Note that E_{11} is the actual energy of the one-dimension confined state, so the energy increase due to quantum confinement is $E_{11}–E_0$. Express your result as a function of (as needed) E, E_{11}, E_0 and Δ.
   d. Compute the effective mass $m*$ at $k = 0$ as a function of E_0 and Δ.
   e. Compute the two-dimensional density of states for a parabolic band with band structure $E(k) = E_0 + \hbar^2 k^2/2m^*$, where the effective mass m^* has the value in part (d). Compare this density of state with the one you calculated in part (b). Explain the result.