Birla Institute of Technology and Science, Pilani

First Semester 2017-18 Mid-Semester Examination (Part A Closed Book)

Course Title: Nanoelectronics & Nanophotonics Course No. EEE G595

Maximum Marks: 60 Maximum Time: 60 Minutes Dated: 9/10/2017

1.(a) From the expression for $h_0(\vec{k}) = -t(1 + 2e^{ik_x a}\cos k_y b)$ for a graphite sheet, use Taylor expansion about a Dirac point (k_xa, k_yb)=$(0, \pm 2\pi/3)$ to obtain the energy dispersion relation for a CNT. Show that within this approximation, we obtain constant-energy contours of circles isotropically disposed around the center of Dirac point. [10]

(b) From the expression of the energy dispersion relation obtained in (a), calculate the minimum energy gap of a ZNT for sub-bands $\nu_1 = 60$ and $\nu_2 = 85$ whose circumferential vector is $\vec{c} = \hat{y}2bm$ where the value of m is 90. [10]

2. From the 3-D Schrodinger equation $\left[E_C - \frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} - \frac{\hbar^2}{2m}\frac{\partial^2}{\partial y^2} - \frac{\hbar^2}{2m}\frac{\partial^2}{\partial z^2} + U(z)\right]\Phi_\alpha(\vec{r}) = E_\alpha \Phi_\alpha(\vec{r})$, obtain a 1-D Schrodinger equation for a z-strip, where electrons are free to move in $\hat{x}$ and $\hat{y}$ direction and there is a confinement along the $\hat{z}$ direction. [10]

3. The Retarded Green's Function for the channel of a one-level device can be given as $G^R(E) = [E - \varepsilon' + i\gamma/2]^{-1}$. Now, from the expression of $G^R(E)$, obtain the expression for the density of states, D(E) in the channel and show that the broadened level in the channel of this one-level device can accommodate exactly the same number of electrons that a discrete level could accommodate before it got coupled to the reservoir. [20]

4. Calculate the Integral transforms:

(a)

$$I(t) = \int_{-\infty}^{\infty} \frac{dE}{2\pi\hbar} e^{-iEt/\hbar} \left(\frac{1}{E - \varepsilon_i + i0^+} \right) \quad [5]$$

(b)

$$I(E) = \int_{-\infty}^{\infty} I(t) e^{+iEt/\hbar} dt \quad [5]$$

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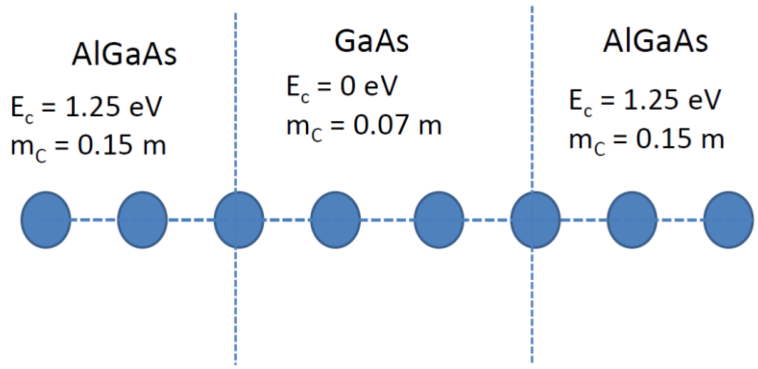
First Semester 2017-18 Mid-Semester Examination (Part A Open Book)

Course Title: Nanoelectronics & Nanophotonics Course No. EEE G595

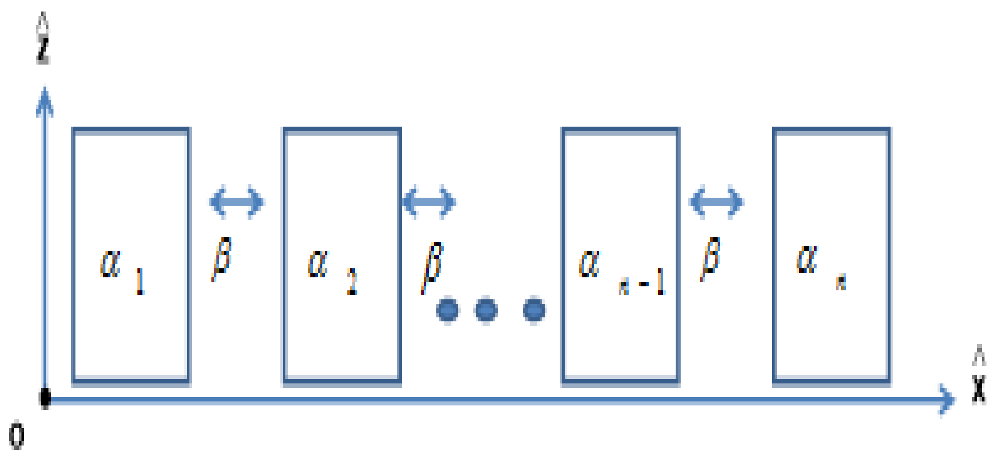
Maximum Marks: 30 Maximum Time: 30 Minutes Dated: 9/10/2017

1. Obtain a 8×8 Tridiagonal Hamiltonian matrix for the following z-strip of AlGaAs/GaAs/AlGaAs by using one-band effective mass equation:



[15]

2. Obtain a Block-Tri-Diagonal Hamiltonian matrix for the channel a nano-scale 2D device which is rectangular lattice is shown is the figure.



[15]

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