Learning Outcomes in Nano-Scale Electronic Devices which is a part of the course entitled "Electronic and Photonic Nano-Scale Devices (EE4001)

Please check if you learned the following items in this course. These are the minimum knowledge that you must gain through this course. If you feel any difficulty to understand any of the items below while attending the lectures, please ask questions and get clarified.

PART-I

1. Do you understand the meaning of Schrodinger's Equation (SE)? How to interpret the wave functions and energies from SE?
2. How to write down the real-space Hamiltonian matrix (H) of a 1D system?
3. How to apply infinite potential well or periodic boundary condition on H and how to find out the Eigen-energy matrix (H_D) and estimate the Eigen-vector matrix (V)?
4. How do the finite boundary and discrete lattice give birth to discrete k-states and Brillouin zone (boundary in k-states), respectively?
5. How can the equilibrium density matrix be identified as the Fermi-function of Hamiltonian matrix? Do you know the calculation steps for spatial electron density as well as the total number of electrons?
6. How to obtain the formulation of tight binding model for E-k relation?
7. How to write the atomistic Hamiltonian matrix [h(k)] in general and specifically for Graphene, Eigen-values of which yields the E-k solutions?
8. What are the factors determining the size of [h(k)] matrix?
9. How to obtain the reciprocal space lattice from the real space lattice and how to mark the Brillouin zone using the knowledge of Weigner-Seitz cell?
10. How to get the formulations behind the sub-bands for quantum wells, quantum wires, quantum dots, nanotubes and what are the boundary conditions involved?
11. How to obtain the zigzag and arm-chair nanotubes and what are the reasons behind the former to be metallic or semiconducting?
12. How to calculate the bandgap of a semiconducting zigzag nanotube?
13. How to obtain the density of states (DOS) of 1D, 2D and 3D crystals with isotropic and anisotropic dispersion relations?
14. How to obtain the conventional expression for DOS of a 3D crystal from the formal expression for DOS?

<u>PART-II</u>

15. How to write the effective mass Hamiltonian h(k) for 1D, 2D and 3D crystals and how is it different from the corresponding atomistic Hamiltonian h(k)?
16. How to obtain a general formulation for an open system, $(E[I]-[H]-\Sigma)\{\psi\}=\{S\}$, and what are the interpretations of its various terms?
17. How to obtain the specific formulation (with 1D chain of atoms), $(E-(E_c+2t_0)+t_0\exp(ika))\{\psi\}=2it_0B\sin(ka)$ and what is the similarity with the general formula?
18. How to calculate Σ under various circumstances and what are the significances of its real and imaginary parts?
19. How to compute the retarded Green's function of the channel from the equation of the open system, $\{\psi\}=[G]\{S\}$?
20. What is the interpretation of the retarded Green's function in time domain and how to obtain its energy-domain expression from the time-domain expression?
21. What are the differences between the total and local density of states?
22. How to compute the spectral function from the delta function of the Hamiltonian?
23. How to compute the local density of states at each point in real space within an energy range?
24. How to compute the total density of states from the information of LDOS or spectral function?
25. How are the energy levels broadened yielding a finite life time to the electron wave-function in the device due to contact with reservoir? Do you know that the broadened level can accommodate exactly the same number of electrons that the one discrete level could accommodate before it got coupled with reservoir?
26. How can the spectral function and the LDOS be obtained from the information of retarded and advanced Green's function through a mathematical identity?
27. How can the spatial density matrix be computed using the LDOS and Fermi function?
28. What is the character of a reservoir from the perspective of channel energy broadening function (γ) or density of states of the reservoir (D_R) and why does the atomic contact behave like a poor reservoir?
29. How to obtain the expression of transmission function from one contact to some other contact?
30. How do the Buttiker probes act as the scattering centers? How to obtain the effective transmission function considering the scattering effects?
31. How to compute current in a nano-wire FET?