Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SEVENTH SEMESTER B.TECH. (E & C) DEGREE END SEMESTER EXAMINATION
NOVEMBER 2018
SUBJECT: NANOTECHNOLOGY (ECE - 4029)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates

- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A. Explain the basic operation of resonant tunnelling diodes and its applications.

1B. (i). **Organic semiconductors**. The energy associated with vacuum (i.e., the absence of matter) is defined to be 0 eV in many organic electronic systems and all energies are referenced as negative values removed from that 0 eV level. The HOMO level of a newly-synthesized π-conjugated polymer resides at –5.2 eV. Researchers have illuminated a thin film of this polymer with a number of different wavelengths of light, and they have found that the longest wavelength of light that will excite an electron from the HOMO level of the polymer to the LUMO level of the polymer is 800 nm. Determine the band gap and the absolute position of the LUMO level, which is defined to be closer to 0 (i.e., less negative) than the HOMO level, of the new polymer.

(ii). Use molecular orbital theory, predict the bond order in H_2^-.

1C. Consider the structure of 1,3,5-hexatriene as shown in Figure 1C. Show that the length of 1,3,5-hexatriene can be estimated to be 0.867 nm. Estimate the amount of energy in the first electronic transition (in eV) for 1,3,5-hexatriene. Given, C=C Double Bonds length=0.135 nm, C-C Single Bond length=0.154 nm, Carbon Radii =0.077nm.

1,3,5-Hexatriene
6 Carbons with sp^2 Hybridized Orbitals

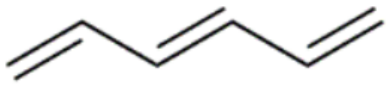


Figure 1C

(4+3+3)

2A. (i). X-rays of an unknown wavelength are diffracted by a gold sample. The 2θ angle was 64.582° for the {220} planes. What is the wavelength of the X-rays used? (The lattice constant of gold =0.40788 nm; assume first-order diffraction, n = 1).

(ii). A sample of bcc metal with the lattice parameter a = 0.33nm was placed in a X-ray diffractometer using incoming x-rays with λ = 0.1541nm. Using Braggs law (assume first order diffraction, n=1) predict positions of the diffraction peaks (in 2Θ) corresponding to {110}, {210}, {230}, {321} and {431} planes. Which of these peaks will be observable?

2B. Explain the technique of laser assisted direct imprinting process with neat diagram.

2C. Figure 2C is the silicon nanowire based biosensors. How the sensor will work if silicon nanowire is replaced by carbon nanostructures.

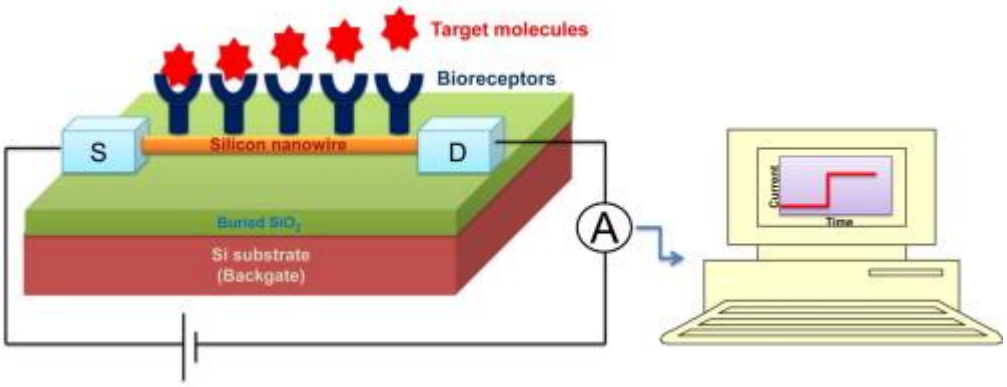


Figure 2C. Silicon nanowire FET based biosensor.

(4+3+3)

3A. Sketch the following within a cubic unit cell. (i) [112] (ii) [3 -1 0] (iii) (11 -1) (iv) (1 -2 1)

3B. Explain the technique to synthesis the Gold Nanoparticles with neat diagram.

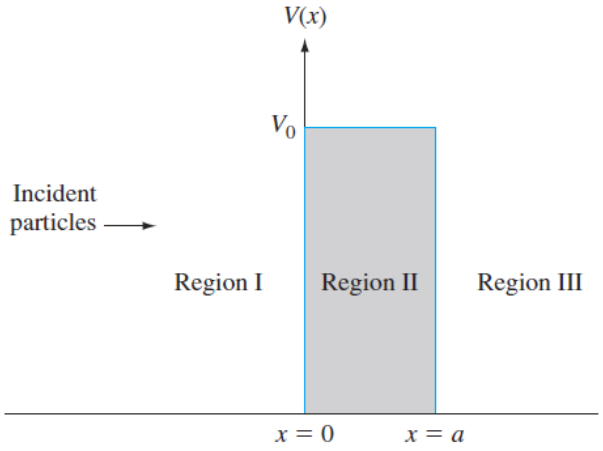
3C. Give the relation of Density of state for 2D nanostructure. Calculate the number of states per unit energy in a 100 by 100 by 10 nm piece of silicon ($m^* = 1.08\, m_0$) 100 meV above the conduction band edge. Write the result in units of eV^{-1}.

(4+3+3)

4A. An electron with energy E is incident on a rectangular potential barrier as shown in Figure 4A. The potential barrier is of width a and height Vo >> E.

(a) Write the form of the wave function in each of the three regions.

(b) Derive the expression for the transmission coefficient for the electron (tunneling probability).



The potential barrier function.

Figure 4A.

4B. How the piezoelectric scanners work in the AFM? Explain the fabrication of polymer based AFM tip fabrication.

4C. Figure 4C is the stadium of coral built by IBM researchers. Using Fe atoms for the corral (diameter =200 pm), the dimensions of this corral are roughly 15 atoms wide or 5 nm x 5nm.Determine the ground-state energy of CO in the corral.

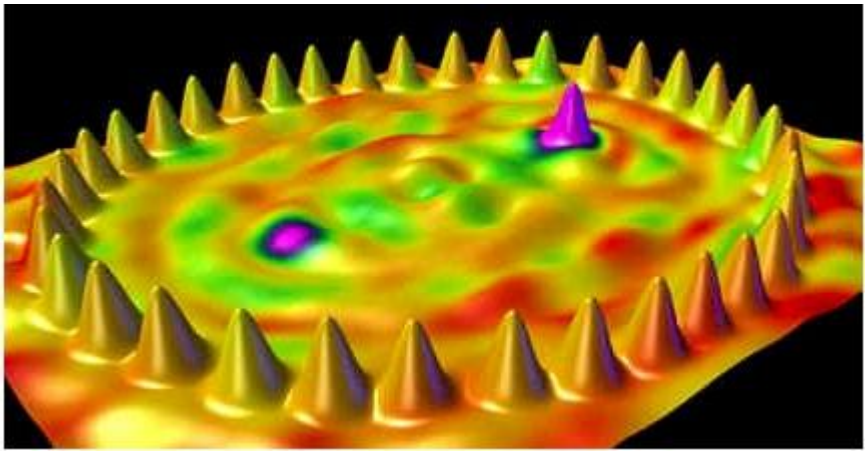


Figure 4C.

(4+3+3)

5A. Determine the width of the forbidden bandgap that exists at $ka=\pi$. (Figure 5A). Assume that the coefficient P'=8 and the potential width is a 4.5 Å.

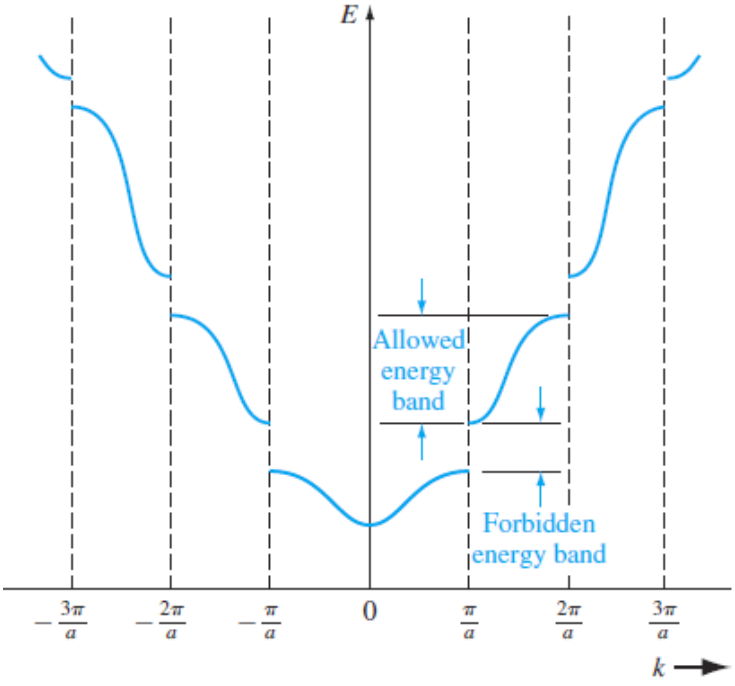


Figure 5A.

5B. Explain the basic construction and working of the SEM with neat diagram.

5C. What is quantum conductance? Derive it.

4+3+3