BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: PRE-PHD **SEMESTER : NA**
BRANCH: EC **SESSION : MO/18**

SUBJECT: EC501 MICROWAVE SEMICONDUCTOR DEVICES

TIME: 03:00 HRS. **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Sketch the bar plot for frequency range of various semiconductor materials such as Si, SiGe, SiC, GaAs, GaN, and InP. [5]

Q.1(b) Compare the electronic properties of Si, SiC, InP, GaAs and GaN in terms of (a) breakdown field, (b) dielectric constant, (c) energy gap, @ 300 K. [5]

Q.2(a) A Ge-GaAs heterojunction bipolar transistor (HBT) has the following parameters: Ge lattice constant, a_1 = 5.646 Å; GaAs lattice constant, a_2 = 5.653 Å; Ge electron affinity, x_1= 4.0 eV; GaAs electron affinity, x_2= 4.07 eV; Ge energy gap, E_{G1} = 0.80 eV; GaAs energy gap, E_{G1} = 1.43 eV; Determine: (a) The lattice match in percent, (**b)** The conduction-band differential between Ge and GaAs, (c) The valence-band differential between Ge and GaAs. [5]

Q.2(b) Sketch the equivalent circuit of tunnel diode connected to a parallel load and write the expression of its power gain. [5]

Q.3(a) A HEMT has the following parameters: gate width, W = 150 μm; electron velocity, v(z) = 2×10^5 m/s; two-dimensional electron-gas density, n(z) = 5.21×10^{15} m^{-2}. Calculate the drain current of the HEMT. [5]

Q.3(b) Diagram the high-frequency equivalent circuit of HEMT required to predict or calculate the values for a small- or large-signal HEMT amplifier. Analyse and write down the typical parameter values. [5]

Q.4(a) Consider an n-type GaAs based Gunn diode with Electron density, $n = 10^{18}$ cm^{-3}; Electron density at lower valley, $n_L = 10^{10}$ cm^{-3}; Electron density at upper valley, $n_U = 10^8$ cm^{-3} @ 300 K. Formulate the conductivity of the diode and solve for it. [5]

Q.4(b) Schematize three-valley-model energy level for InP diode and Write the three-valley model theory. [5]

Q.5(a) Design a structure with semiconductor material to realize a Read diode along with doping profile and field distribution. Write various regions on the structure to express their roles and characteristics. [5]

Q.5(b) An IMPATT diode has the following parameters: Carrier drift velocity $v_d = 2\times10^7$ cm/s, Drift-region length L = 6 μm, Maximum operating voltage V_{Omax} = 100 V, Maximum operating current I_{Omax} = 200 mA, Efficiency η=15% and Breakdown voltage v_{bd} = 90 v. Compute (a) the maximum continuous wave (CW) output power in watts; (b) the resonant frequency in gigahertz. [5]

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