Ex/MECE/520/2024

M.Tech. VLSI Design and Microelectronics Technology, 2024
First Year First Semester

SEMICONDUCTOR AND PHOTONIC DEVICES AND MODELLING

Time: **3 Hours** Full Marks: **100**

Answer ***any FIVE*** Questions.

1.a)	What are the different types of Metal-Semiconductor contacts and how do they differ? What criteria distinguish the different types of Metal Semiconductor Contacts?	4
b)	What is a heterojunction? Name a pair of lattice matched compound semiconductors widely used in device applications. Why semiconductors with closely matching lattice constants are required for heterojunction?	4
c)	The lattice mismatch between the substrate and epitaxial material in a heterojunction is 5% and the lattice constant of epitaxial material is 6.1 Å. What is the critical thickness of the epitaxial layer over the substrate material? What will happen to the deposited epitaxial material if the critical thickness is exceeded?	3+3
d)	How is ΔE_C and ΔE_V determined from the electron affinities and band gaps of the associated materials of a type 1 heterojunction.	6
2.a)	What is Scaling?	4
b)	Why constant voltage scaling was used in early phase of integration (1970-1990) and why was it necessary to go for constant field scaling at a later phase.	4
c)	How the threshold voltage V_T scales under constant voltage and constant field scaling.	8
d)	What is the reason for using non uniform doping in modern CMOS technology?	4
3.a)	Derive the *I-V* characteristic of an MESFET.	10
b)	Reduce the general equation for I-V characteristic for linear and saturation region and find out the output conductance and trans-conductance of the MESFET for linear and saturation region respectively.	10
4.a)	Define the following with respect to an n-p-n bipolar junction transistor and the relationship between them: (i) Base transport factor, B	8

	(ii) Emitter efficiency, γ_e (iii) Current transfer Ratio, α (iv) Current amplification factor, β.	
b)	How the condition for high current gain β in a homo-junction BJT leads to conflicting requirements and how it is resolved in a Heterojunction Bipolar Transistor?	6+4
c)	How are cutoff currents I_{CBO} and I_{CEO} related?	2
5.a)	What is a Transferred Electron Device?	4
b)	Derive the condition for origin of negative differential resistance in transferred electron Devices.	12
c)	Summarize the necessary requirements of materials suited for a transferred electron device?	4
6.a)	What is the threshold gain for Lasing in a Laser diode?	10
b)	How does optical confinement in the active zone affect the threshold gain?	4
c)	How does Double Heterostructures improve performance of Semiconductor Lasers?	6
7. a)	What is the response time of a photodetector and why it is important?	4
b)	Explain the factors on which the response of a photodetector depends?	6
c)	Why the response time of a PIN photodetecctor is much better than a p-n junction diode?	4
	Show that the response time of an avalanche photodiode increases linearly with gain.	6
8.	Write notes on ***any FOUR***:	4x5
a)	Varactor diode	
b)	Early Effect	
c)	Channel length modulation in FET	
d)	Modulation Doping	
e)	CMOS inverter	
f)	Stimulated emission.	