

1059

M.Tech. (Material Science and Technology)
Second Semester

MST-204: Semiconductors and Optoelectronic Materials

Time allowed: 3 Hours

Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Unit.

x-x-x

1. Attempt all parts of this question. (2 x 5 = 10)
- (a) What are fuel cells? Write the advantages and disadvantages of such type of cells.
 - (b) Explain the optical susceptibility of a semiconductor?
 - (c) What are degenerate and nondegenerate semiconductors?
 - (d) What are photo resist materials? Write three examples of each type of these materials.
 - (e) Explain the term mean time failure (MTF) of a conductor due to electromigration in the Al metallization.

Section -A

2. (a) Explain why a shaped beam promises higher throughput than a Gaussian beam in e-beam lithography. How can alignment be performed for e-beam lithography?
 (b) The seed crystal used in Czochralski process is usually necked down to a small diameter (5.5 mm) as a means to initiate dislocation free growth. If the critical yield strength of the silicon is $2 \times 10^6 \text{ gm/cm}^2$, calculate the maximum length of a silicon ingot 200 mm diameter that can be supported by such a seed. (5,5)
- 3 (a) Explain why high temperature RTA is preferable to low temperature RTA for defect free shallow-junction formation.
 (b) Why is <100>-orientation preferred in NMOS fabrication? What problems occur if a polysilicon gate is used for gate lengths less than 3 micron? Can another material be substituted for polysilicon? (5,5)
- 4 (a) What are bimolecular recombination coefficients? Explain these by giving suitable examples.
 (b) Find the etch selectivity required to etch a 400-nm polysilicon layer without removing more than 1 nm of its underlying gate oxide, assuming that the polysilicon is etched with a process having 10% etch-rate uniformity. (5,5)

Section B

- 5 (a) What are ferro-piezoceramic materials? How are these materials useful for the industry purposes by giving few examples?
 (b) At 300 K, an ideal solar cell has a short circuit current of 3 A and an open-circuit voltage of 0.6 V. Calculate and sketch its power output as a function of operating voltage and find its fill factor from this power output. (5,5)
6. Write briefly about the following: (5,5)
- (a) Scattering mechanisms in semiconductors
 - (b) Ionic conductivity in semiconductors
- 7 (a) Find out the gain and current generated when $1.5 \mu\text{W}$ of optical power with $h\nu = 3\text{eV}$ is shone onto a photoconductor of $\eta = 0.9$ and a minority carrier lifetime of 0.55 ns. The material has an electron mobility of $3 \times 10^3 \text{ cm}^2/\text{V-s}$, electric field is 4000 V/cm and $L = 8 \mu\text{m}$.
 (b) Write short note on thin film capacitors. (5.5)

x-x-x