Solid State Device and Technology (EC56)

1. **The PN Junction Diode:** Introduction, Space Charge Region: Formation of Region, Barrier Voltage and Energy Bands, Drift and Diffusion Currents, Analytical Relations of Equilibrium: Electrostatics of Space charge region, Constancy of the Fermi Level, Built-In Voltage in terms of Fermi Potential, Built-in Voltage in terms of Doping Densities, Electric Filed and Potential in space charge region, width of space charge region, conditions in the diode with voltage applied, currents in diode: motion of carriers with bias applied, conditions with forward bias, conditions with reverse bias, assumptions for ideal diode equation, solution of continuity equation, currents crossing junction, the current loop, saturation current, boundary condition at junction, general equation for hole distribution in the N-region of PN junction diode.

2. **Fabrication Technology:** Introduction, Why Silicon, The purity of Silicon from sand, the Czochralski growing process: the melt and the dopant, seed crystal, Ingot slicing and wafer preparation, fabrication processes: thermal oxidation, etching techniques, diffusion, expressions for diffusion of dopant concentration, Ion implantation, photomask generation, photolithography, epitaxial growth, metalization and interconnections, ohmic contacts, planar PN junction diode fabrication, fabrication of resistors and capacitors in IC's.

3. **Bipolar Transistors -I: Characteristics and First Order Model** Introduction, Structure and Basic operation, fabrication of bipolar integrated circuit transistor, terminology, symbols, modes of operation, circuit arrangements, transistor currents in active region: emitter current collector current, base current, base current as a control current, fixing I_B or V_{BE}, transistor parameters, graphical characteristics and modes of operation: CE active mode, CE saturation mode, CE cutoff mode, CE inverse active mode, CB active mode, CB saturation mode, CB cutoff mode, analytical relations for the currents: assumptions and procedure, emitter current, collector current, relations for NPN transistor, recombination current in the base, expression for alpha and beta, Ebers-Moll Model.

4. **Bipolar Transistors -II: Limitations, Switching and Models** Introduction, Effects of limitations on static Characteristics: increase of collector current with V_{CE} in forward active region, carrier multiplication and breakdown, punch through effects at very low and high injection: very low injection and current gain, high level injection and Kirk effect at the base collector junction, high level injection at the emitter base junction. Transistor switching: Stored charge and transit time, charge control relations, turn-ON time, turn-OFF time. Small signal equivalent circuit: effects of charges in V_{BE}, carrier processes, small signal currents and circuit elements, capacitance effects, effects of

changes in magnitude of V_{CB} : carrier processes, collector current change, recombination current change, complete equivalent circuit, figure of merit, NPN transistor, the Gummel-Poon Model.

5. **Junction Field Effect Transistors:** Introduction, construction and operation: construction and the basic functions of the terminals, operation, current-voltage characteristic equation: preliminary conditions, derivation of current voltage relationship, additional remarks, channel conductance and JFET transconductance, secondary effects: channel length modulation, breakdown, variation in mobility, temperature effects, small signal equivalent circuit, figure of merit to the JFET, high frequency limitations.

6. **Metal Semiconductor Junction and Devices:** Introduction, Energy band diagrams of metal and N-semiconductor: before contact, thermal equilibrium conditions of metal and N-semiconductor after contact. Schottky barrier, Schottky barrier diode: rectifying metal-N semiconductor contact, properties of depletion layer, rectifying metal-P semiconductor junction.

7. **Metal Oxide Silicon Systems:** Introduction, energy band diagrams, band bending and the effect of bias voltages: The effects of bias voltage. Analytical relations for the charge densities: depletion region thickness and charge density.

8. **Metal Oxide Semiconductor Field Effect Transistors (MOSFET):** Introduction, construction and basic operation, fabrication of N-type MOSFET (NMOS) on an integrated circuit chip: isolation process, poly silicon, the deposition of SiO_2, Silicon Nitride and poly silicon, basic steps in fabrication, regions of operation: Cutoff region, Linear region, saturation region. Types of MOSFETs, control of threshold voltage, measurement of MOS transistor parameters, MOSFET small signal equivalent circuits: low frequency circuit, high frequency circuit, high frequency performance: the f_t of the MOSFET, comparing the MOSFET and BJT, the MOSFET switch and CMOS inverter: the Inverter, resistor inverter, enhancement Load inverter, the CMOS inverter, switching of inverter.

Text Book:

1. Integrated Electronics (Analog and Digital Systems)-Jacob Millman, Christos C.Halkias

2. Microelectronics-Jacob Millman Arvin Grabel