Course Title: Electrical Engineering Materials
Course Code: EEEG 207
Credit Hours: 3

Course Description:
The course provides basic understanding of the most commonly used materials in electrical and electronics engineering. The section on semiconductor materials will lay the foundation for understanding the solid-state devices analysed and applied in later courses.

Course Contents:

Unit 1: Introduction
Materials science: Definition, Fields of study, Brief introduction to the most commonly used technological materials- metals, semiconductors, Ceramics, Polymers, Glasses, and composites; Types of properties: Thermal, Mechanical, Chemical, Electrical, Optical, and magnetic; Applications of materials science: examples- microelectronics and computers, Strengthening mechanisms and aerospace applications, Fast breeder reactor, Fuel cells and electric batteries, Biomedical materials, Low-cost housing.

Unit 2: Crystal Structure
Lattice, Basis, simple crystal structures, Packing fraction, and Zinc blende

Unit 3: Fundamentals of Electron Theory
Wave-particle duality; The Schrodinger equation, Solution of the Schrodinger equation for free electron, electron in a potential well, and tunnel effect; Electron in periodic field of a crystal (without detail derivation); Band theory of solid metals, Insulators and semiconductors.

Unit 4: Theory of Metals
Free electron theory and energy well model of a metal; Density of states function; Fermi-Dirac distribution function; Electrons in a crystal-energy band theory of solids- metals, Semiconductors and insulators; Conductivity of metals-relaxation time, Collision time and mean free path; Effect of temperature on the resistivity of metals; Thermionic emission and work function; Contact potential.

Unit 5: Superconductivity
Historical introduction, Properties of super conducting materials, Theories (qualitative description only), and applications

Unit 6: Semi-Conductor Fundamentals
Crystal structure of group- IV materials and band structure; Intrinsic semiconductors; Extrinsic semiconductors: n-type and p-type; Density of states in semiconductors; Fermi-Dirac distribution, Fermi factor and Fermi level; Effect of temperature on Fermi level; Law of mass action; Mobile and immobile charges; Mobility, drift and diffusion; Conductivity in semiconductors; Hall effect; Continuity equation- injected minority carrier charge; Semi-conductor PN junction: built in potential, Depletion width, P-N junction with no-bias, Forward-

bias and reverse-bias conditions, Rectifier equation, Junction capacitance, junction diode switching times, and metal - semiconductor contact.

Unit 7: Semi-conductor Devices
Photodiode, Light emitting diode, Tunnel diode, Breakdown diodes, varactor diode; Bipolar Junction Transistor (BJT); Junction Field Effect Transistor (JFET); Metal Oxide Semiconductor Field Effect Transistor (MOSFET); Photo transistor (working principle, Characteristics, Parameters, and typical applications.)

Unit 8: Introduction to Integrated Circuit Fabrication
Monolithic integrated circuit technology; the planar processes- crystal growth on the substrate, Epitaxial growth, Oxidation, Photolithography, Diffusion, Ion implantation, and metallization; typical example

Unit 9: Magnetic Properties of Materials
Classification based on atomic dipoles- dia-, para-, ferro-, ferri-, and antiferro-magnetism; Origin of permanent magnetic dipole in matter; Curie-Weiss Law; Hysteresis and eddy-current loss in magnetic materials; Applications of magnetic materials

Unit 10: Optical Properties of Materials
Refractive index, Penetration depth, Absorbance, Reflectivity, and transmissivity; Classical considerations

Unit 11: Dielectric Properties:
Polarisation and dielectric constant- ionic, Electronic and orientational polarisation; Ferro electricity and piezoelectricity; Frequency dependence of polarizability (qualitative discussion only); Dielectric losses

References:
1. R.E. Hummel, *Electronic Properties of Materials*, 2nd Ed., Narosa Publishing House
2. B.G. Streetman, *Solid State Electronic Devices*, PHI.
3. A.J. Dekkar, *Electrical Engineering Materials*, PHI.
4. J. Millman and C.C. Halkias, *Integrated Electronics*, Tata McGraw Hill.