25SC801 Ferroelectric Materials and Devices 3 1 0 4

Course Overview

To provide the theoretical foundation for ferroelectricity and related phenomena, and to discuss ferroelectric materials and devices.

Course Outcome:

After learning the course, the students should be able to:

CO1	Identify fundamentals of linear and non-linear dielectrics
CO2	Develop the fundamental knowledge of ferroelectric phenomena and explain their basic principles
CO3	To notify the learner about the various techniques of nano-thin films
CO4	To know about the growth of nanostructured thin films
CO5	Develop an awareness regarding the applications of ferroelectrics

Course Syllabus

Unit1

Dielectric ceramics: Pauling's Rule and Crystal structure of ceramics, Ceramic materials: Crystal structure, Defect Chemistry, Non-Stoichiometric oxides, Concentration and effect of intrinsic impurities, Intrinsic ionization in metal oxides, Brouwer's Diagram.

Linear Dielectrics: Dielectric displacement and polarization mechanism, Dielectric polarizability, Frequency dependence of dielectrics. Classification of Ionic solids: Losses in dielectric materials, Frequency dependence of dielectric constant, dipolar relaxation, Debye equations for dipolar relaxation, Impedance spectroscopy.

Unit2

Nonlinear dielectrics: Piezoelectrics and Pyroelectrics: Impedance spectroscopy and dielectric breakdown, Basics of non-linear dielectrics, Piezoelectric effect, Pyroelectric effect.

Ferroelectrics: Basics of ferroelectric materials, Ferroelectric phase transitions, Thermodynamics of phase transitions in ferroelectric materials, Second order phase transitions in ferroelectric materials, First order phase transitions in ferroelectric materials,

Domain walls in ferroelectric materials, Domain structure and properties of ferroelectric materials, Phase diagram and measurements of ferroelectric materials

Unit3

Materials and device designing and fabrication processes: Bulk / Composites, Basics of Thin films and Nanostructures, Role of thin films in Devices, Fabrication of thin films: Sol-gel synthesis, Spin coating, Chemical vapor deposition, Physical vapor deposition, Sputtering deposition, ion implantation, Cathodic arc deposition, Pulsed laser deposition, Molecular beam epitaxy, Characterization of thin films: x-ray diffraction, UV-vis spectroscopy, squid, four probe resistivity, atomic probe microscopy, profilometer, Properties of thin films: Structural, electrical, magnetic, optical, thermal, etc., Application of thin films: Application of thin films in different areas such as electronics, medical, defence, sports, automobiles, etc.

Unit4

High Permittivity Dielectrics: Relaxor Ferroelectrics, Chip Capacitors, Hybrid Substrates; Ferroelectric Memory Devices, Composite Ferroelectric Materials, Multiferroics

Text Books

1. Materials Science of Thin Films – Milton Ohring
2. Thin Film Phenomena – K. L. Chopra
3. Ferroelectric Devices, Kenji Uchino, Marcel Dekker, 2000.
4. Dielectric Phenomena in Solids, Kwan Chi Kao, Elsevier, 2004.

Reference Books

1. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties & Applications" Imperial College Press, 2004.
2. Thin Film Processes – J. L. Vossen and W.Kern
3. Ferroelectric Devices, Kenji Uchino, Marcel Dekker, 2000.
4. Dielectric Phenomena in Solids, Kwan Chi Kao, Elsevier, 2004.
5. Electroceramics, Herbert & Moulson, Chapman & Hall, 1993.
6. Physics of Ferroelectrics - A Modern Perspective, Ed. Karin M. Rabe Charles H. AhnJean-Marc Triscone, Springer-Verlag Berlin Heidelberg, 2007.
7. Ferroelectric Memories, J.F. Scott, Springer Verlag, 2000.

Evaluation Pattern

Internals(50%)

Continuous Assessment - 20

Mid-Term - 30

Externals(50%)

End Semester - 50