MTPC3005 CHARACTERIZATION OF MATERIALS (3-0-0)

Objectives of the Course:
The course aims to introduce students to the fundamental principles and practical applications of various material characterization techniques. It focuses on crystallographic, microstructural, and chemical analysis using diffraction, microscopy, and spectroscopy. The objective is to enable students to select the appropriate characterization tools for analyzing metals, ceramics, and polymers.

Module - I: (06 hours)
Introduction and Optical Microscopy:
Importance of material characterization, classification of techniques. Principles of Optical Microscopy: Resolution, magnification, depth of field, numerical aperture. Lens defects and corrections. Techniques: Bright field, Dark field, Polarized light, and Phase contrast microscopy. Sample preparation for metallography (grinding, polishing, etching).

Module - II: (06 hours)
X-Ray Diffraction (XRD):
Production and properties of X-rays. Bragg's Law and diffraction conditions. Structure factor and intensity of diffracted beams. Diffractometer geometry and instrumentation.

Module - III: (06 hours)
X-Ray Diffraction (XRD Application):
Applications: Crystal structure determination, phase identification, and residual stress measurement.

Module - IV: (06 hours)
Electron Microscopy (SEM):
Interaction of electron beam with matter: Secondary electrons, Backscattered electrons, Characteristic X-rays. Scanning Electron Microscopy (SEM): Construction, electron gun sources (Thermionic vs. Field Emission), resolution, and depth of focus. Contrast mechanisms in SEM.

Module - V: (06 hours)
Transmission Electron Microscopy (TEM) and Microanalysis:
Transmission Electron Microscopy (TEM): Basic principle, construction, and imaging modes (Bright field/Dark field). Selected Area Diffraction (SAD) patterns. Chemical Analysis: Energy Dispersive Spectroscopy (EDS) and Wavelength Dispersive Spectroscopy (WDS) – principles and quantitative analysis.

Course Outcomes:
CO1: Understand the fundamental principles of optical microscopy and apply metallographic techniques for proper sample preparation and microstructural examination.
CO2: Interpret X-ray diffraction (XRD) patterns to identify crystal structures, phases, and lattice parameters of crystalline materials.
CO3: Explain the working principles of Scanning Electron Microscopy (SEM) and utilize electron-matter interactions to analyze surface morphology.
CO4: Analyze internal microstructures and chemical compositions at the nanoscale using Transmission Electron Microscopy (TEM) and Energy Dispersive Spectroscopy (EDS).

Books:
1. Elements of X-Ray Diffraction by B.D. Cullity, Pearson Education.
2. Microstructural Characterization of Materials by D. Brandon and W.D. Kaplan, Wiley.
3. Materials Characterization by Yang Leng, Wiley.

Reference Books:
1. Scanning Electron Microscopy and X-Ray Microanalysis by J. Goldstein et al., Springer.
2. Transmission Electron Microscopy by D.B. Williams and C.B. Carter, Springer.
3. Characterization of Materials by E.N. Kaufmann, Wiley-Interscience.

Digital Learning Resources:

Course Name: Materials Characterization Course Link: https://nptel.ac.in/courses/113/106/113106034/ Course Instructor: Prof. S. Sankaran, IIT Madras

Course Name: Modern Instrumental Methods of Analysis Course Link: https://nptel.ac.in/courses/103/108/103108100/ Course Instructor: Prof. J.R. Mudakavi, IISc Bangalore