MATERIAL CHARACTERIZATION

Course Code	20ME4601D	Year	III	Semester	II
Course Category	Professional Elective-II	Branch	ME	Course Type	Theory
Credits	3	L-T-P	3-0-0	Pre-requisites	Applied Physics, Chemistry of Materials, Material Science and Metallurgy
Continuous Internal Evaluation	30	Semester End Evaluation	70	Total Marks	100

Course outcomes At the end of the course, the student will be able to

CO	Statement	Skill	Blooms	Units
CO1	Discuss the principle and operation of Light microscopy, Scanning Electron and Transmission Electron Microscopy	Understand, Communication	L2	1,2,3
CO2	Summarize the principle and operation of different characterization tools such as optical microscope, Scanning electron microscopes and transmission electron microscope	Understand, Communication	L2	1,2,3
CO3	Interpret changes in materials using X-ray and thermal analysis techniques.	Understand, Communication	L2	4,5
CO4	Select the characterization tool for specific application	Apply	L3	1,2,3,4,5

Contribution of Course Outcomes towards achievement of Program Outcomes & Strength of correlations (3-High, 2: Medium, 1: Low)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3					2		2	3	1
CO2	3	2	2	2	3					2		2	3	1
CO3	3	2	2	2	3					2		2	3	1
CO4	3	2	2	2	3					2		2	3	1

Syllabus

UNIT	Contents	Mapped CO
I	**Light Microscopy:** Optical Principles-Image Formation- Resolution, Effective Magnification, Brightness and Contrast, Depth of Field, Aberrations. **Instrumentation:** Illumination System- Objective Lens and Eyepiece, Specimen Preparation. **Imaging Modes:** Bright-Field and Dark-Field Imaging, Phase Contrast Microscopy, Polarized Light Microscopy, Nomarski Microscopy, Fluorescence Microscopy, Confocal Microscopy.	CO1 CO2 CO4
II	**Electron Microscopy:** Introduction, Need of electron microscopy, Key advantages and disadvantages of imaging with electrons, Interaction of electrons with materials, Elastic versus inelastic electron scattering, Signals from the specimen, material features analysis using electron microcopy. **Scanning Electron Microscopy (SEM):** Key features of the SEM microscope, SEM Specimen preparation, SEM detectors, Key microstructural features analyzed by SEM, Specimen shape, Specimen	CO1 CO2 CO4

	composition, Surface crystallography.	
III	**Transmission Electron Microscopy:** Key features of the TEM microscope, TEM specimen preparation, TEM imaging modes- Bright-field (BF) imaging, Electron diffraction, High-resolution TEM (HRTEM), Scanning TEM (STEM), High angle annular dark field (HAADF), **TEM spectroscopy:** X-ray analysis in TEM (EDX), Electron energy loss spectrometry, Key applications of TEM. Specimen changes during imaging, Strategies for minimizing specimen damage: Outlook for SEM and TEM.	**CO1** **CO2** **CO4**
IV	**X-ray diffraction (XRD) techniques for materials characterization:** Introduction, Principles of X-ray diffraction techniques, Generation of X-ray radiation, Diffraction of X-ray by crystalline materials. **Special methods:** Energy-dispersive X-ray diffraction, Small angle scattering, In situ X-ray diffraction, Hardware for X-ray diffraction measurements with laboratory equipment: X-ray source, Goniometer, Primary optics, Secondary optics, Detectors. **Applications:** Measurement of diffraction patterns by X-ray diffraction, Qualitative phase analysis. Quantitative phase analysis: Method with external standard, Method with internal standard, Method of intensity ratio, Rietveld method.	**CO3** **CO4**
V	**Thermal Analysis:** Common Characteristics-Thermal Events, Instrumentation Experimental Parameters. **Differential Thermal Analysis and Differential Scanning Calorimetry:** Working Principles, Temperature-Modulated Differential Scanning Calorimetry Experimental Aspects, Measurement of Temperature and Enthalpy Change, Applications. **Thermogravimetry:** Instrumentation, Experimental Aspects Interpretation of Thermogravimetric Curves, Applications**.**	**CO3** **CO4**

Learning Recourse(s)

Text Book(s)

1. Materials Characterization Using Nondestructive Evaluation (NDE) Methods. (2016). Netherlands: Elsevier Science.
2. Mitra, P. K. Characterization of Materials. PHI Learning Pvt. Ltd., 2013.
3. Leng, Yang. Materials characterization: introduction to microscopic and spectroscopic methods. John Wiley & Sons, 2009.

Reference books

1. B.D.Cullity and S.R.Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall,NJ, 2001.
2. David B. Williams, C. Barry Carter, " Transmission Electron Microscopy: A Textbook for Materials Science", Springer, pub. 2009.
3. Zhang, Sam, Lin Li, and Ashok Kumar. Materials characterization techniques. CRC press, 2008.

e- Resources & other digital material

1. https://nptel.ac.in/courses/115/103/115103030/
2. https://onlinecourses.nptel.ac.in/noc20_mm14/preview
3. https://www.classcentral.com/course/swayam-materials-characterization-7978