

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Metallurgy
SUBJECT NAME: Materials Characterization
SUBJECT CODE: 2172109
B.E. 7th SEMESTER

Type of course: Engineering Science

Prerequisite: Knowledge of Engineering Materials, Metallurgy and basic science skills

Rationale: The Material Characterization course is to prepare students for careers in metallurgy engineering where knowledge of characterization techniques leading to the advancement of research and technology. Knowledge of characteristic features and their identification such as thermal properties, metallography, surface morphology, chemical properties, crystal structure etc. of the materials is must for a metallurgist to select a candidate material for a given engineering application as well as to provide solution of a given metallurgical task. This course will help students in their project work during graduation, to solve different metallurgical problems upon graduation while at the same time, provide a firm foundation for the pursuit of graduate studies in metallurgy engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	0	2	6	70	30	00	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Importance of Material characterization, Classification of techniques for characterization.	02	3
2	Vacuum systems: Vacuum range, Vacuum Pumps: Rotary, Sorption, Turbomolecular, Diffusion, Ion, Cryo. Vacuum measurement gauge: Pirani, Penning, Ionization etc. Use of Vacuum systems in Material Characterization techniques.	07	12
3	Thermal Analysis techniques: Principle, Working and application of DTA, TGA, TMA and DSC.	06	10
4	Optical microscopy techniques: Metallurgical Microscopes, Aberration in Optical microscopy & its remedies, Polarized light in microscopy, Differential Interference Contrast Illumination, Hot Stage Microscopy, color metallography, and image analysis techniques.	08	13
5	Electron microscopy: Electron beam. Principle, Construction and Working of TEM, SEM, STEM, with their merits, limitations and applications. Techniques of	08	14

	replica preparation.		
6	Atomic Microscopy: Field Ion Microscope, Working of AFM and STM with their merits, limitations and applications.	06	10
7	Spectroscopic Techniques for chemical analysis:, UV-Visual(UV-VIS), IR, FTIR, EDS & WDS, X-ray Fluoroscapy (XRF), Atomic absorption spectrometer(AAS), Atomic Emission spectroscopy (AES). Secondary Ion mass spectrometry (SIMS), Rutherford backscattering spectroscopy (RBS)	11	18
8	Diffraction method: Bragg's Law, X-ray diffraction methods, determination of crystal structure, lattice parameter, crystallite size, merits and demerits	06	10
9	Surface characterization: XPS (ESCA), UPS, Auger Electron Spectroscopy, Electron Probe Micro Analysis (EPMA), LEED.	06	10
Total		60	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	30	40	10	05	00

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. F. Weinberg Editor, Tools & Techniques in Physical Metallurgy, Vol. I & II, Marcel Dekker
2. John P. Sibilila, A guide to Material Characterization & Chemical Analysis, VCH Publishers, 1988.
3. J.M. Walls, Editor, Methods of Surface Analysis : Techniques & Applications, Cambridge University Press, 1990.
4. B.D. Cullity, Elements of X-ray diffraction, Addison-Wesley Publishing Company, INC.,
5. Bernhard Wunderlich, Thermal Analysis, Academic Press, INC, 1990.
6. B.L. Gabriel, SEM : A user's manual for materials Science, American Society for Metals
7. An Introduction to Materials Characterization by P. R. Khangaonkar, Penram International Publishing (India) Pvt. Ltd.

Course Outcome:

After learning the course the students will be able to:

1. Explain importance & Classification of Characterization Techniques.
2. Describe use of Vacuum systems in Material Characterization techniques.
3. Explain working of Thermal Analysis techniques.
4. Describe the principal and methods of different optical microscopy techniques for observation of Microstructure.
5. Describe the principal and methods of different electron and atom microscopy techniques.
6. Explain Chemical & Elemental Analysis for a given engineering application.
7. Explain identification techniques of crystal structure, lattice parameter & crystallite size of different materials using X-ray diffraction.

8. Understand and explain surface morphologies of different Materials including coated & surface treated-materials, new alloys etc.
9. Demonstrate the ability to use the core concepts of engineering application for Material characterization techniques.

List of Experiments:

1. To study introduction and importance of material characterization techniques.
2. To study different vacuum systems and measurement.
3. To study Thermogravimetric Analysis for oxidation rate measurement.
4. To Study Differential scanning calorimetry technique.
5. To analyze the microstructure and measure the grain size using image analyzer.
6. To study principle and working of Scanning Electron Microscope.
7. To study working, merits, limitations and applications of AFM and STM.
8. To study X-ray Fluoroscopy.
9. To study the diffraction pattern using powder diffraction pattern and to predict the lattice parameter and structure of crystal.
10. To study XPS with relative merits and demerits.

Design based Problems (DP)/Open Ended Problem:

1. Chart of different vacuum systems.
2. Chart of different thermal Analysis techniques.
3. Chart of different Optical microscopy techniques.
4. Chart of different electron and atom microscopy techniques.
5. Chart of different Spectroscopic Techniques for chemical analysis.
6. Problems based on brag's law.
7. Chart of different X-ray diffraction methods.
8. Chart of different Surface characterization techniques.
9. Collection and Study of various samples of coated & surface treated-materials, new alloys etc.
10. Group discussion and Presentations on Recent trend in material characterization.
11. Any other problem decided by faculty based on syllabus.

Major Equipment: Metallurgical Microscope, Image analyzer system etc.

List of Open Source Software/learning website:

1. <http://nptel.iitm.ac.in/>
2. www.ocw.mit.edu
3. www.btechguru.com