MSE-232 Characterization Techniques

Credit Hours: 3-0

Pre-requisites: Nil

Course Objectives

The course deals with studying the structure of materials at both micro and macro level using various types of microscopes and diffraction methods. Various techniques used for the determination of chemical nature and composition of various materials will be taught. Methods to evaluate various physical and chemical properties of materials will be presented.

Course Contents

Introduction to characterization techniques and their application in Materials science and Engineering

Production and absorption of X-rays; use of filters; X-ray diffraction and Bragg's law; structure factor calculations; diffraction methods; Debye-Scherer camera; Laue back-reflection; and rotating-crystal method. XRD spectrum and its Indexing; Precise lattice parameter determination; Particle size and micro/macro strains calculations. Chemical analysis by X-ray fluorescence.

Stereographic projections; orientation of crystal with respect to a reference; rotation of crystal around an axis; planes of a zone. Crystal structure determination; single crystals orientation; pole figures; Applications of X-ray diffraction.

Scanning electron microscope (SEM); construction and working principle; interaction of electrons with matter; modes of operation; image formation of plane and fractured surfaces. Energy Dispersive X-rays and wavelength dispersive X-rays systems.

Electron diffraction and basics of transmission electron microscopy (TEM); Image formation; resolving power and magnification; depth of focus; elementary treatment of image contrasts; important lens defects and their correction. Bright field and dark field images. Spectroscopic techniques, spark emission spectroscopy, absorption spectroscopy etc. Thermal analysis of materials.

Course Outcomes

At the end of the course, students will be able to:

- Compare the operating principles, capabilities, limitations, and applications of various characterization techniques used in materials engineering.
- Interpret the data generated from various characterization tools such as XRD, electron microscopes, spectroscopy, and thermal analysis.

- Select an optimum characterization technique for a given material under different circumstances.

Weekly Plan

Week	Topics
1	Introduction to characterization techniques and their application in Materials science and Engineering
2	Production and absorption of X-rays; use of filters; X-ray diffraction and Bragg's law
3	structure factor calculations; diffraction methods; Debye-Scherer camera; Laue back-reflection; and rotating-crystal method
4	
5	XRD spectrum and its Indexing; Precise lattice parameter determination; Particle size and micro/macro strains calculations. Chemical analysis by X-ray fluorescence.
6	
7	Stereographic projections; orientation of crystal with respect to a reference; rotation of crystal around an axis; planes of a zone. Crystal structure determination; single crystals orientation; pole figures; Applications of X-ray diffraction
8	
9	**Mid-Semester Exams**
10	Scanning electron microscope (SEM); construction and working principle; interaction of electrons with matter; modes of operation; image formation of plane and fractured surfaces. Energy Dispersive X-rays and wavelength dispersive X-rays systems;
11	
12	Electron diffraction and basics of transmission electron microscopy (TEM); Image formation; resolving power and magnification; depth of focus.
13	
14	Elementary treatment of image contrasts; important lens defects and their correction. Bright field and dark field images.
15	
16	Spectroscopic techniques, spark emission spectroscopy, absorption spectroscopy etc. Thermal analysis of materials.
17-18	**End Semester Exams**

Suggested Books

- Materials Characterization: Modern Methods and Applications edited By N. (Mohan) Ranganathan, 1st ed. Jenny Stanford Publishing (2015)
- Characterization of Materials, 3 Volume Set by E. N. Kaufmann. 2nd ed. Wiley, (2012)
- X-Ray Diffraction by B. D. Cullity. 3rd ed. Prentice Hall, (2001)