Characterization of Materials - Web course

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Physics

COURSE OUTLINE

Characterization of materials is essential to the systematic development of new materials and understanding how they behave in practical applications. This course focuses on the principal methods required to characterize broad range of materials such as metal, alloys, semiconductors, insulators, polymers, ceramics, nanostructures etc. for their applications based on mechanical, electrical, optical, magnetic, thermal properties of materials.

The topics covers structure analysis tools, microscopy techniques, thermal analysis technique, electrical characterization, magnetic characterization, and optical spectroscopy, and other techniques for characterization of nanophase materials. The aim of this course is to provide introductory understanding of number important techniques in terms of the instrumentation, working principles, and information obtained and possible analysis of the materials.

This course is targeted towards undergraduate and postgraduate students of physics, materials science, metallurgy, energy technology, electrical engineering and electronics, polymer science and engineering etc.

Contents:

Introduction to materials and Techniques,*Structure analysis tools:* X-ray diffraction: phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models, Neutron diffraction, Reflection High Energy Electron Diffraction, and Low Energy Electron Diffraction; *Microscopy techniques:* Optical microscopy, transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDS), scanning electron microscopy (SEM), Rutherford backscattering spectrometry (RBS), atomic force microscopy (AFM) and scanning probe microscopy (SPM); *Thermal analysis technique:* Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermogravimetric analysis (TGA); *Electrical characterization techniques:* Electrical resistivity, Hall effect, Magnetoresistance;

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Magnetic characterization techniques: Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method, Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance; *Optical and electronic characterization techniques:* UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy. The interested users may also go through other similar courses such as **Materials Characterization** by Dr. S. Sankaran and Prof. Viajaya Agarwala; and **Advanced Characterization Techniques** by Dr. K. Biswas and Dr. Gurao.

COURSE DETAIL

Sl. No.	Module/ Lecture Topics	No. of Hours
1	**1. Introduction** Introduction to materials and Techniques	01 (01)
2	**2. Structure analysis tools:** X-ray diffraction	01 (02)
3	Phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models	03 (05)
4	Neutron diffraction; Reflection High energy electron Diffraction (RHEED), Low energy Electron Diffraction (LEED)	03 (08)
5	**3. Microscopy techniques:** Introduction to Microscopes, Optical microscopy (OM)	02 (10)
6	Transmission Electron Microscopy (TEM); Basic Electron scattering, Concepts of resolution, TEM instruments, Various imaging modes, Analysis of micrographs,	06 (16)

	Electron Energy Loss Spectroscopy	
7	Scanning Electron Microscopy, Rutherford backscattering spectrometry	02 (18)
8	Atomic Force Microscopy, Scanning Probe Microscopy	02 (20)
9	**4. Thermal analysis techniques:** Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermo-gravimetric analysis (TGA)	03 (23)
10	**5. Electrical characterization techniques:** Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance	04 (27)
11	**6. Magnetic characterization techniques:** Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method	03 (30)
12	Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance	06 (36)
13	**7. Optical characterization techniques:** UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy	04 (40)
	Total	**40**

References:

1. Characterization of Materials (Materials Science and Technology: A Comprehensive Treatment, Vol 2A & 2B, VCH (1992).

2. Semiconductor Material and Device Characterization, 3rd Edition, D. K. Schroder, Wiley-IEEE Press (2006).

3. Materials Characterization Techniques, S Zhang, L. Li and Ashok Kumar, CRC Press (2008).

4. Physical methods for Materials Characterization, P. E. J. Flewitt and R K Wild, IOP Publishing (2003).

5. Characterization of Nanophase materials, Ed. Z L Wang, Willet-VCH (2000).