11. Introduction to Properties of Materials – Daniel Rosenthal and Robert M Asimow (Affiliated East-West Press, 1974)
12. Physical Metallurgy Principles – R E Reed Hill (Affiliated East –West Press, 1974)
13. Physical Metallurgy – S H Avner (Tata McGraw-Hill, 1997)
14. Mechanical Metallurgy – George R Dieter (McGraw-Hill, 1988)
15. Structure and Principle of Engineering Materials – V S R Murthy (Tata McGraw Hill- 2003)
16. Polymer Science –V R Gowarikar, N V Viswanath, Jayadev Sridhar (Wiley Eastern, 2015)
17. Polymer Science and Technology – Joel R Fried (Prentice Hall, 1993)
18. Principles of Polymer Science – Bahadur P, Sastry N V (Narosa, 2005).

MSH 452 MATERIALS TESTING AND CHARACTERIZATION (4 Credits)

Objectives: The key objectives are to (i) familiarize students with various non-destructive techniques for material characterization. (ii) prioritize the requirement of vacuum technology in the design of instrumentation for materials testing. (iii) categorize the selection of relevant characterization techniques for specific materials.
Expected course outcomes: By the end of this course, (i) students will be able to describe various non-destructive testing techniques and basic vacuum technology. (ii) students will select the suitable characterization technique to study the given property of a material (iii) students able to analyse the test results obtained. (iv) the student acquires the necessary skills for working in industries associated with vacuum technology and in companies dealing with the sales and service of scientific instruments.

Unit I

Fundamentals of vacuum techniques: Basic concepts of pumping: idealgas -pressure, density, mean free path. Regions of gas flow - molecular and viscous flow. Conductance of a pipework, pipework in parallel and series - fundamental equation of vacuum technology, simple problems. Vacuum pumps: operating limits of a pump. Rotary, vapour diffusion, turbomolecular, cryogenic, UHV and ion pumps - a brief survey of working principles. Vacuum measurement: thermal conductivity gauges, Pirani and thermocouple gauges, ionisation gauges, hot and cold cathode ionisation gauges - working principle and operating limits. Vacuum materials. 18 hours

Unit II

Non-destructive testing of materials: Introduction, different types of testing, ultrasonics- principles - ultrasonic receivers and oscillators - transducers, probes. Reference and calibration blocks. Identification and seizing of defects.

X-Ray radiography: principles -factors affecting contrast and resolution.

Neutron radiography: neutron sources and detectors. Methods- criteria for evaluating flaw detection by neutron radiography method. Factors limiting the contrast. Comparison of X-ray and neutron radiography methods.

Mechanical testing of materials: Tensile and compression tests - Brittle and ductile failure - Universal testing machine. Hardness test – Moh's scale, indentation hardness- Brinell, Vicker and Rockwell hardness numbers and related experiments. Impact test - Izode and Charpy tests. Fatigue test - a brief discussion. 18 hours

Unit III

Materials characterisation: Electron microscopy- Interaction of electron with matter. Transmission microscopy (TEM) - principles, sample preparation. Kinematic theory of contrast. Imaging modes – bright and dark field modes. Scanning Microscopy (SEM) - principles, beam diameter, image contrast. Applications to microstructure determination. Scanning probe microscopy- principles and applications.

Atomic and molecular spectroscopies: atomic absorption, Infrared, and Raman spectroscopies for the determination of impurities. Low energy electron diffraction (LEED), X-ray photoelectron spectroscopy (XPS/ESCA) and Auger electron analysis - principles and applications for surface studies. Electron probe micro analysis (EPMA) and Energy dispersive analysis of X-rays (EDAX) - principles and applications for compositional analysis. 14 hours

References

1. Fundamentals of Vacuum Techniques - A Pipco et al (MIR, 1984)
2. Vacuum Technology - A Roth (North Holland Pub. Co., 1982)
3. Modern Vacuum Physics - Austin Chambers (Chapman and Hall, 2005)
4. Ultrasonics - B Carlin (Mc Graw Hill, 1960)
5. Applied X– Rays - George L Clark (Mc Graw Hill, 1955)
6. Principles of Neutron Radiography - N D Tyufyakov and A S Shtan (Amerind, 1979)
7. Modern Metallographic Techniques and Their Applications - V A Phillips (Wiley Interscience, 1971)
8. Handbook on Ultrasonic Testing of Materials - Ramesh B Parikh (Electronic & Engineering Co., 1984)
9. Testing of Metallic Materials - A V K Suryanarayana (Prentice Hall India, 1990)
10. Physical Metallurgy Part 1 - R W Cahn and P Haasen (Ed) (North Holland, 1983)
11. Ultrasonic Testing of Materials - Krautkramer, (Narosa Publishers, 1990)
12. Instrumental Methods in Chemical Analysis - G W Ewing (Mc Graw Hill, 1975)
13. Scanning Electron Microscopy and X-ray Micro Analysis - Joseph I Goldstein, (Plenum Press, 1992)
14. The Principles and Practice of Electron Microscopy: Ian M Watt, (Cambridge Univ. Press, 1997)

MSS 453 SURFACE PHENOMENA AND ELECTROCHEMISTRY (3 Credits)

Objectives: This course aims to (i) provide a comprehensive structure-property relationship between the surface of a material and the chemical and physical phenomena. (ii) introduce various catalytic reactions of industrial use. (iii) interpret kinetics and mechanisms in solid-state reactions. (iv) explain the theory of electrolytic conductance and electrochemical phenomena of strong electrolytes on electrode surfaces and their applications (iv) teach corrosion behaviour in materials and protection from corrosion.

Expected course outcomes: By the end of the course, students will be able to (i) distinguish between physical and chemical adsorption phenomena in different catalytic processes in industry and research. (ii) measure the surface area of catalytic powders and classify them based on their porosity. (iii) apply the principles of electrochemical measurements to develop electrode materials for sensors and battery applications in their careers. (iv) describe the nature of corrosion in materials and protection.