

**Department of Post Graduate Studies & Research in Physics & Electronics
Rani Durgawati University, Jabalpur**

**Value Added Add-on Course (w.e.f. 2020-21)
(In Accordance with University Ordinance No. 222)**

**Certificate Course on
“Material Characterization Techniques”**

Course Code: PY VA-001

Time Duration: 30 Hrs.

Course Objectives:

1. The course will give the students the necessary skills to carry out the characterizations of the materials, in the first instance within their project and master projects.
2. Students will be exposed to the knowledge base required to understand how an AFM operates.
3. To develop key concepts – both theoretical and experimental – which allow a better understanding of the principles underlying the AFM.
4. Students will be motivated to carry out the development of nano-indentation instruments using extremely low loads and depths.
5. This course is customized to meet the specific needs for the electrical characterization of the materials.

Course Outcomes:

1. The students should be able to perform analytical, experimental and theoretical characterization of the different materials.
2. Users/Students of AFM have the opportunity or resources to rapidly acquire the interdisciplinary knowledge that allows an intelligent operation of this instrument.
3. This course will solve in-depth knowledge by presenting a unified discussion of the fundamentals of atomic force microscopy.
4. This course introduces nano-indentation system, which takes the technology several steps further, resulting in a high resolution nano-indentation instrument which will capable to generate mechanical characterization of the materials.
5. This course thoroughly and systematically covers the fundamentals of Impedance measurement, the principle and steps involved in electrical characterization of the materials.

Theory Course			Marking Scheme					
Paper Code	Title of Paper		Credits	End exam.	CCE	Total	Min. Marks	
PY VA-001	Certificate Course on “Material Characterization Techniques”		5	60	40	100	35	
Practical Course			CCE			Total	Total	
			End exam.	Practical Record & Viva	Seminar related to Practical			
PY VAL-001	Lab	3	60	20	20	40	100	35
Total			8	120	80		200	

PY VL-001 MATERIAL CHARACTERIZATION TECHNIQUES (THEORY COURSE)

60+40 = 100 MARKS

5 CREDITS

Course Content

Unit-I

Fundamentals of Characterizations of Material

Necessity of Characterization of materials; External & Internal properties of material; Basic theoretical aspects relating Surface, Structural, thermal, mechanical and Electrical characterization; Principles, techniques and instruments used in characterization of materials including chemical, thermal, micro and nano-structural, and surface analysis of materials for metals, ceramics, polymers, and semiconductor systems.

Unit-II

Surface Characterization by Atomic Force Microscopy (Part-1)

Tip-Surface Interactions (Non-Contact): Intra-Molecular Interactions; Electric Dipoles; Inter-Molecular Interactions:- Physical Models; Inter-Molecular Interactions:- Ion-Dipoles; Inter-Molecular Interactions:- Keesom Force; Inter-Molecular Interactions:- Dispersion Force.

Tip-Surface Interactions (Contact): Hamaker constant; Surface Energies; Derjaguin Approximation; Elasticity of Materials; Contact Mechanics; Hertz, JKR, DMT.

Unit-III

Surface Characterization by Atomic Force Microscopy (Part-2)

Basic concepts in Atomic Force Microscopy (AFM) instrumentation; The AFM stage; AFM electronics; Acquisition software; AFM cantilevers and Probes; AFM instrument environment; Scanning environment; Force curves; Processing, Displaying & Analyzing AFM Images.

Unit-IV

Mechanical Characterization by Micro & Nano Hardness Tester

Relationship of Hardness to Other Material Properties; Nano Hardness Tester (NHT); Principle of the NHT; Key advantages of the NHT: Displacement and force stability, Thermal drift, Stability of the normal force & adhesion measurement, Frame compliance; Indentation parameters: low load indentations, Creep studies on polymers, Stress-strain characteristics; Statistical analysis of large sets of indentation data; Applications of the NHT.

Unit-V

Electrical Characterization by Dielectric measurement & Impedance Analyzer

Charging and discharging of dielectric materials and current/charge measurement under isothermal and thermally stimulated conditions; Dielectric constant and dielectric loss measurement; Dielectric breakdown.

AC Circuit Analysis; Introduction to Linear circuits; Phasors; Impedance; Optimizing measurement conditions: Frequency, Signal level, Measurement speed, Measurement range, DC bias; Measuring level-dependent elements: Voltage dependence, Current dependence; Effect of contact resistance; Analysis of AC impedance.

PY VAL-001 MATERIAL CHARACTERIZATION TECHNIQUES (PRACTICAL COURSE)

60+40 = 100 MARKS

3 CREDITS

Practical hands on the operation and working of instruments and analysis of results based on theory content.

References:

1. Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films, Editors: C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston, US, ISBN-10: 0750691689/ISBN-13: 978-0750691680
2. Atomic Force Microscopy by Peter Eaton & Paul West, Oxford University Press, ISBN-10: 0199570450/ISBN-13: 978-0199570454.
3. Fundamentals of Atomic Force Microscopy by Ronald Reifenberger, World Scientific Publishing Co. Pte. Ltd., ISBN: 978-981-4630-36-8.
4. The IBIS Handbook of Nanoindentation by Anthony C. Fischer-Cripps, Fischer-Cripps Laboratories Pty Ltd., ISBN: 0 9585525 4 1.
5. Electrical Impedance: Principles, Measurement, and Applications by L. Callegaro, CRC Press, Taylor & Francis Group Publication, ISBN: 9781439849101.
6. Callister's Materials Science & Engineering by R. Balasubramanian, Wiley India (P) Ltd., ISBN 10: 81-265-1076-5/13:978-81-265-1076-4.
7. Material Science by S.L. Kakani & A. Kakani, New Age International Publishers, ISBN: 81-224-1528-8.