Specialization: Advanced Fabrication and Experimental techniques

Semester-III	
Course Code	**Course Name**
21MSP605T	Advanced Experimental and Characterization Techniques-1
21MSP606T	Advanced Experimental and Characterization Techniques-2
21MSP607T	Advanced Fabrication Techniques
21MSP619P	Advanced Fabrication and Experimental Techniques Laboratory
21MSP601	Project-I
	Semester-IV
	Project - II

<table>
<tr><th colspan="5">M.Sc. Course</th><th colspan="6">21MSP605T- Advanced Experimental and Characterization Techniques-1</th></tr>
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COURSE OBJECTIVES

- To introduce the various advanced microscopic methods that used for the materials characterization.
- To provide basics and working of magnetic and electric characterization techniques.
- To introduce the principle and methods of various diffraction techniques and structure analysis.
- To provide the basic understanding of data analysis and operation of different characterization equipment.

UNIT 1: Optical Microscopy	**8 Hrs.**
Introduction to Microscopy, Metallurgical Microscopes and Image formation, Resolution, Aberrations in Optical microscopy & its remedies, Polarized light in microscopy, Differential Interference Contrast Illumination, Hot Stage Microscopy, color metallography, andImaging modes, Specimen preparation, Confocal microscopy.	
UNIT 2: Electron Microscopy:	**11 Hrs.**
Brunauer-Emmett-Teller (BET) Electron-materials interactions,Scanning electron microscopy (SEM) Transmission electron microscopy (TEM), High resolution TEM (HRTEM), *TEM electron energy loss spectroscopy* (EELS), High-angle annular dark-field imaging (HAADF), Electron backscatter diffraction (EBSD), Selected area diffraction (SAD), Laser Confocal Microscopy. Surface profiling. Scanning probe microscopy(SPM),Scanning tunneling microscope (STM), Atomic force microscope (AFM) Working principles, working modes, Image artifacts	
UNIT 3: Diffraction technique & structure analysis	**12 Hrs.**
X-ray diffraction, Reflection High energyelectron Diffraction (RHEED), Low energyElectron Diffraction (LEED), Neutron diffraction **Structure analysis** energy dispersive X-ray analysis (EDXA), Wavelength-dispersive X-ray spectroscopy (WDXS or *WDS*), Extended X-ray absorption fine structure (EXAFS), Surface-extended X-ray absorption fine structure (SEXAFS), X-ray absorption near edge structure (XANES), High Power X-ray(Syncrotron) **Various SAXS technique** Small-angle X-ray scattering (SAXS), Grazing-incidence small-angle X-ray scattering (GISAXS)	
UNIT 4: Magnetic and Electric characterization techniques:	**9 Hrs.**
Measuring Magnetization by Induction Method, Vibrating Sample Magnetometer (VSM), SQUID, AC susceptibility technique Types of Measurements Using Magnetometers, Types of Measurements Using AC susceptibility, Magneto-optic Kerr effect (MOKE) or the surface magneto-optic Kerr effect (SMOKE), Nuclear Magnetic Resonance Spectroscopy (NMR), Electron Spin Resonance Spectroscopy (ESR) **Electric** Electrical resistivity in bulk and thin films, electron beam induced current measurement (EBIC), Hall effect, Magnetoresistance.	
	Max. <40> Hrs.

COURSE OUTCOMES

After completion of this course students will be able to;

CO1:Demonstrate an understanding of various advanced microscopic techniques.

CO2:Ability to recognize the appropriate microoscopic methods and apply them to various materials to obtain desired information.

CO3:Understand of different diffraction techniques and able to analyze and determine structure of various materials

CO4:Acquire knowledge about the different magnetic and electrical characterization techniques.

CO5: Summarise and compare the result of different advanced methods for highly resolved microscopy.

CO6: Analyse and interpret the data acquired from different characterization methods and came up with relevant conclusions.

TEXT/REFERENCE BOOK

1. Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, Y. Leng, John Wiley & Sons (Asia), 2013.(2nd Edition)
2. Materials characterization techniques, Sam Zhang, L. Li & Ashok Kumar, Boca Raton: CRC Press, 2009.
3. Principles of Instrumental Analysis, D.A. Skoog, F.J. Holler, S. R. Crouch, Cengage Learning, 2018 (7th Edition).
4. Surface Analysis: The Principal Techniques, J.C. Vickerman, I. Gilmore, John Wiley &Sons, Inc., 2009 (2nd Edition).
5. Experimental techniques in materials and mechanics, C Suryanarayana, CRC Press , Year: 2011
6. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Prof. Yang Leng(auth.), Wiley-VCH, Year: 2013

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COURSE OBJECTIVES

- To introduce the various advanced spectroscopic methods that used for the materials characterization.
- To provide basics and working of thermal analysis.
- To introduce the principle and methods of various non-destructive testing techniques.
- To provide the basic understanding of data analysis and operation of different characterization equipment.

UNIT 1: SPECTROSCOPIC METHODS-1	**9 Hrs.**
UV-visible spectroscopy-Beer’s law, Instrumentation, Quantitative analysis; Principles of vibrational spectroscopy, Vibrational spectroscopy-Raman and Infrared, Fourier transform infrared spectroscopy (FT-IR), Instrumentation, Micro Raman spectroscopy, applications, Photoluminescence spectroscopy (PL), Mossbauer spectroscopy, Applications.	
UNIT 2: SPECTROSCOPIC METHODS-2	**11 Hrs.**
Atomic model and electron configuration, Principles of X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES), Chemical shift, Depth profiling, Instrumentation, Applications, Scanning Auger spectroscopy (SAM), Ultra-violet photoelectron spectroscopy (UPS), Electron spectroscopy for chemical analysis (ESCA), X-ray fluorescence analysis (XRF), Electrochemical impedance spectroscopy (EIS); Ion beam techniques: Rutherford backscattering spectrometry (RBS), Secondary-ion mass spectrometry (SIMS).	
UNIT 3: NON-DESTRUCTIVE TESTING	**12 Hrs.**
Elastic recoil detection analysis (ERDA), Proton induced x-ray emission (PIXE); Radiography: Introduction, Production of X-rays, working principle X-Radiography, Applications and Safety aspect, Various methods for detecting X-rays; Ultrasonic: Frequency and generation, Piezo-electric Materials for Ultrasonic Transducers, Different kind of Ultrasonic Transducers, Working of Ultrasonic Flaw Detectors, Industrial applications, Acoustic emission, Thermography, Holography, Basic principles, Applications in airframe and rocketry.	
UNIT 4: THERMAL ANALYSIS	**8 Hrs.**
Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Thermomechanical analysis (TMA) and Dynamic mechanical thermal analysis (DMTA), Thermoptometry, Basic theory, Instrumentation and applications.	
Max. <40> Hrs.	

COURSE OUTCOMES

After completion of this course students will be able to;

CO1: Demonstrate an understanding of various advanced spectroscopic techniques.
CO2: Ability to recognize the appropriate spectroscopic methods and apply them to various materials to obtain desired information.
CO3: Develop a basic background of different non-destructive testing techniques and be able to relate them to principles of physics.
CO4: Acquire knowledge about the different thermal analysis techniques and understanding the working principle.

CO5: Apply the fundamentals of thermodynamics extract useful qualitative and quantitative information from thermal analysis.
CO6: Analyse and interpret the data acquired from different characterization methods and came up with relevant conclusions.

TEXT/REFERENCE BOOK

1. Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, Y. Leng, John Wiley & Sons (Asia), 2013.(2nd Edition)
2. Experimental techniques materials and mechanics, C. Suryanarayana, Boca Raton: CRC Press (2011)
3. Materials characterization techniques, Sam Zhang, L. Li & Ashok Kumar, Boca Raton: CRC Press, 2009.
4. Principles of Instrumental Analysis, D.A. Skoog, F.J. Holler, S. R. Crouch, Cengage Learning, 2018 (7th Edition).
5. Surface Analysis: The Principal Techniques, J.C. Vickerman, I. Gilmore, John Wiley & Sons, Inc., 2009 (2nd Edition).
6. Non-Destructive Testing Techniques, Ravi Prakash, New Academic Science Limited, 2012.
7. Introduction to Thermal Analysis, Techniques & Applications, Brown, Kluwer Academic Publishers, 2004.
8. Practical Non-Destructive Testing, B. Raj, T. Jayakumar, M. Thavasimuthu, Alpha Science International Limited, 2007 (3rd Edition).

M.Sc.					21MSP607T- Advanced Fabrication Techniques					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Develop the knowledge of applications and the necessity of advanced semiconductor fabrication techniques.
- Obtain the fundamental understanding of semiconductor processing.
- Apply the acquired knowledge of thin-film growth to the various semiconductor devices
- Develop the skills in solving various real-world problems in the semiconductor device processing and engineering aspects.
- Develop the knowledge of coating in biomedical applications

UNIT 1 Advanced Lithography Techniques	10 Hrs.
Photolithography overview, wet etching, dry etching, Lift-off, Deep UV lithography, E-beam lithography, Focused ion-beam lithography, Laser lithography, X-ray based lithography, Nanoimprint lithography, Soft lithography, Self-assembly and self-organization, Interference and Grayscale lithography	
UNIT 2 Physical Deposition Techniques	**12 Hrs.**
Introduction to the cleanroom, substrate, Preparation methods: Bottom-up Synthesis-Top-down Approach: Thermal evaporation, Thermal oxidation, Atomic Layer Deposition, E-Beam, Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields in Plasmas, Sputtering Mechanisms), Mechanical Milling, Vapour phase deposition, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.	
UNIT 3 Chemical Deposition Techniques	**10 Hrs.**
Chemical vapor deposition (CVD), metal-organic chemical vapor deposition (MOCVD), Colloidal routes, sol-gel, Self-assembly, Electrochemical deposition, Precipitation, Spin coating, blade coating, spray coating, printing, roll to roll, etc.	
UNIT 4 Materials in Medical	**8 Hrs.**
Introduction, medical use of nanomaterials, drug delivery, applications of nanoparticles in drug delivery, proteins and peptide delivery, nanotechnology in the treatment of neurodegenerative disorders, Applications in ophthalmology: surgery, visualization, tissue engineering, nano pharmaceuticals, etc.	
	Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Explain the basic concepts of various techniques of lithography.

CO2 – Identify and design the lithography processing for critical device architecture.

CO3 – Identify and rationalize physical and chemical deposition techniques.

CO4 – Explain the necessity and mechanism of various physical deposition techniques for semiconductor industries.

CO5 – Differentiate and explain the various thin film deposition techniques by a chemical reaction approach.

CO6 – Explain and apply the necessity of nanocoating in medical science.

TEXT/REFERENCE BOOKS

1. The Material Science of thin films by Milton Ohring.

2. Coatings on Glass (volume 6) by H. K. Pulker.
3. Langmuir Blodgett films (volume 3) by C. W. Pitt, G. G. Roberts.
4. Handbook of thin film Technology by Frey, Hartmut, Khan and Hamid R.
5. Thin film Technology and Application by K. L. Chopra & L. K. Malhotra.
6. Deposition Technology for films and coatings by Rointan F. Bunshah.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 3 Questions from each unit, each carrying 3 marks	36 Marks
Part B/Question: 2 Questions from each unit, each carrying 8 marks	64 Marks

					21MSP619P-Advanced Fabrication and Characterization Lab					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**Viva**	
0	**0**	**6**	**3**	**6**	**-**	**-**	**-**	**50**	**50**	**100**

COURSE OBJECTIVES

- To obtain practical knowledge of fabrication and characterization techniques.
- To give hands-on experience of film growth technique.
- To give hands-on experience of various characterization techniques and understand their working mechanism.

List of Experiments

1. Powder x-ray diffraction studies of given bulk material and measuring the crystallite size
2. Determination of charge carrier mobility and concentration in a given semiconductor using Hall Effect set up.
3. Determine the sheet resistivity using four probe method.
4. Work function measurement by Kelvin probe.
5. Develop a given pattern using photolithography.
6 UV-VIS measurement of given thin film sample.
7. Raman analysis studies of given sample.
8. Study of scanning electron microscopy (SEM) analysis of given sample.
9. Study of chemical microanalysis of given sample by energy dispersive X-ray analysis (EDXA)
10. Measurement of thermo gravimetric analysis (TGA) of given sample.

COURSE OUTCOMES

On completion of the course, the students will be able to
CO1 – Identify and explain the various fabrication and design the mini-projects
CO2 – Understand the charge transport mechanism in semiconductor and interpret the data.
CO3 – Extract the fundamental information of any semiconductor.
CO4 – Have hands-on experience of the sample preparation and data analysis from different charecterization tools.
CO5 – Able to explain the working mechanism of various tools used in materials analysis.
CO6 – Apply information literacy/research skills to assist their systematic process of critical thought.

TEXT/REFERENCE BOOKS

1. Materials Science and Engineering, G.S. Upadhyaya and Anish Upadhyaya, Viva books, 2010 2.
2. Fundamentals of Materials Science-the microstructure-property relationship using metals as model systems, E.J. Mittemeijer, Springer, 2010
3. Microstructural Characterization of Materials – D. Brandon and W.D. Kaplan, John Wiley and Sons, 2008
4. Science of Microscopy, P.W. Hawkes and J.C.H. Spence, Springer, 2007
5. Scanning Electron Microscopy & X-Ray Microanalysis, J.Goldstein et.al, Springer, 2003