AC – 07/07/2023

Item No. – 6.2 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in Materials Science } -2024-25

B- M.Sc. (Materials Science) (Two year) } -2024-25

C- M.Sc. (Materials Science) (One year) -2027-28

University Department of Physics (Autonomous)

Syllabus for

Semester – Sem I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1. Introduction: The Master's degree programme in Materials Science is an interdisciplinary course in physics and chemistry. Teaching has a comprehensive focus on functional groups with options for specialising in synthesis, characterisation and modelling. The programme trains candidates who can contribute to interdisciplinary solutions and provides in-depth skills through conducting a significant academic project.

During the first year of your studies in the Master's in Materials Science program, you will deepen the basic knowledge acquired for your Bachelor's degree. At the same time, the knowledge and skills in two specialized areas are built up to follow the current state of research. In the second year of study, an individual research project in the form of a "Master Thesis" is completed within one of the many materials science research teams. The outstanding infrastructure of the University of Stuttgart makes the broad selection of these fields of specialization possible. The current catalog offers the following for instance: Advanced materials characterization Functional Materials Inorganic materials chemistry Materials Theory and Simulation, Metals and Structural Materials, Nanomaterials and Surfaces, Plastics engineering and Soft Matter and Bio-Materials. During the next academic year 2024-25, University Department of Physics is proposing to start a new PG programme in M.Sc. (Materials Science) under NEP-2020 program with effect from academic year 2024-25.

2:Aims and Objectives: Create the facilities and environment in all the educational institutions to consolidate the knowledge acquired at +2+3 level and to motivate and inspire the students to create deep interest in Materials science, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Materials Science.•Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classroom.

3: Learning outcomes:

I. The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in Materials Science.

II. The students would be able to progress in their academic performance through structured curricula.

III. The students would be able take up competitive exams in different sectors, can be entrepreneurs and succeed in higher education in Materials Science.

IV. The students would be able to experience a well resourced environment for learning Materials Science

V. To motivate and inspire the students to create deep interest in Materials Science, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Materials Science.

4: Any other points:

I. During the course work students will be provided hands on training on highly sophisticated state of art equipments. Students will be provided internship at the various government lab and nearby industries.

II. Collaborative activities with national and international institutes/industries to cater the need of regional development.

R:________________

5. Credit Structure of the Program (Sem I, II, III & IV) (Table as per with sign of HOD and Dean)

PG Program in M.Sc. (Materials Science) as per NEP 2020 Structure

The University department of Physics proposes to introduce 1 PG degree program namely M.Sc.(Materials Science) with 30 seats. At present this is proposed programme at the Department of Physics. During the next academic year, Department of Physics may plan to start the programme.

Credit Distribution Structure for One Year PG /Two Years M.Sc. (Materials Science)

Year	Level	Sem	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Elective					
1	6.0	Sem 1	3 x 4 + 2 x 1 – 14	4	4	--	--	22	
			MS-(501) Applied Mathematics	MS-(505) Elective 1 (List attached)	MS-(506) Research Methodology	--	--		
			MS-(502) Foundation of Quantum Mechanics						
			MS-(503) Fundamentals of Materials Science						
			MS-(504) Practical-1						
		Sem 2	3 x 4 + 2 x 1 = 14	4	--	4		22	
			MS-(511) Chemistry of Materials	MS-(515) Elective 2 (List attached)	--	MS (516) Research Project			
			MS-(512) Solid State Devices						
			MS-(513) Modeling of Materials						
			MS-(514) Practical-2						
Cum. Cr. for PG Diploma			28	8	4	--	4	44	
Exit Option: 1 yr PG Diploma (44 credits) after Three Year UG Degree									

Year	Level	Sem	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Elective					
2	6.5	Sem 3	3 x 4 + 2 = 14	4	--	--	4	22	
			MS-(601) Methods of Materials Synthesis	MS-(605) Elective 3 (List attached)	--	--	MS-(606) Research Project		
			MS-(602) Materials Characterizations						
			MS-(603) Materials Composites						

			MS-(604) Practical-3						
		Sem 4	MS-(611)- Research Project (22)- (It is one semester research project to be carried at Materials Industry.)						
Cum. Cr. for 1 yr PG Degree				28	8	--	--	8	44
Exit Option: 1 yr PG Degree (44 credits) after Four Year UG Degree									
Cum. Cr. for 2 yr PG Degree				56	16	4	--	14	88
Exit Option: 2 yr PG Degree (88 credits) after Three Year UG Degree									

LIST OF ELECTIVES

	Elective 1 MS-(505A-505H)	**Elective 2 MS-(515A-515H)**	**Elective 3 MS-(605A-605H)**
A	Materials and their Applications	Plastics	Nuclear Materials
B	Materials Processing Techniques	Aerospace Materials	Spintronics
C	Metallurgy	Liquid Crystals	Nanomaterials
D	Thermodynamics of Materials	Semiconductor Materials	Atomic and Molecular Clusters

VABambole

Sign of HOD

Prof. Vaishali A. Bambole
Department of Physics
Professor & Head
Department of Physics
University of Mumbai

Garje

Sign of Dean

Prof Shivram Garje
Science and Technology

Department of Physics (Autonomous)

University of Mumbai

Programme outcomes of M.Sc. (Materials Science)

1. To navigate learners towards the frontiers of Materials Science
2. To establish a world-class academic programme, with dual emphasis on foundational teaching and active participation in frontier research
3. To establish the best in class infrastructure for facilitating the process of learning and research with core strengths of the Department
4. To nurture learning in various sub-disciplines of Materials Science viz Theoretical, Experimental and Computational, expanding into areas of Materials Science
5. To network with national and global academic institutions through vibrant exchange programmes and collaborations in teaching and research
6. To instill in the learners the spirit of inquiry and innovation
7. To create opportunity platforms for nucleation and incubation of entrepreneurs
8. To build synergistic channels for productive knowledge transfer and utilization through industry partners
9. To create value added linkages and career opportunities for faculty and students through effective networking both at national and international levels
10. To ensure the creation of responsible personnel through engagement in socially relevant outreach programmes

M.Sc.(Materials Science)

PROGRAMME SPECIFIC OUTCOMES (PSO)

The programme ensures that the learners

1. Acquire core competency in the areas of Basic and Applied Materials Science (PSO1)
2. Are exposed to the state-of-art facilities in the Department and collaborating institutions in the neighbourhood (PSO2)
3. Are familiarized with current trends in a wide variety of sub-disciplines and emerging areas of Materials Science (PSO3)
4. Are able to apply their acquired skills in other interdisciplinary areas of science and technology(PSO4)
5. are equipped with knowledge to engage in teaching in academic institutions, research in National research laboratories and R&D based industries as also initiating technology based entrepreneurship (PSO5)

Applied Mathematics

The course commences with a unit on **Matrices and Tensors**; the vector spaces are discussed in the light of matrices and tensors. The emphasis is on solving eigen value problems as they appear in Classical and Quantum Mechanics and other applied areas of Physics. The basics of tensor analysis are introduced to understand the formulation of Relativistic Electrodynamics and other advanced areas of theoretical Physics. The unit on **Functions of Complex Variables** has a review of complex numbers and the algebra and discusses the calculus of complex variables with Cauchy Riemann for analytic functions, Caucy Goursat theorem, Cauchy's integral formula and the Residue theorem and its application in solving complex and real integrals. The units on **Differential Equations** introduces the Frobenius method of series solution of linear differential equations and the associated polynomial solutions of Legendre, Laguerre, Hermite and Bessel functions. The **Integral Transforms** of Fourier and Laplace and their application in solving linear differential equations and **partial differential equations** are discussed. The Green's function method of solving differential equations is addressed.

Course Outcomes:

At the end of the course the learner will be able to

1. Solve eigenvalue problems using matrices as they appear in Classical and Quantum Mechanics (CO1)
2. Apply tensor analysis to understand the formulation of relativistic electrodynamics and other areas of Physics (CO2)
3. Apply residue theorem of complex variables to solve real and definite integrals (CO3)
4. Understand the emergence of special functions as solutions of differential equations and to solve problems in physics (CO4)
5. Solve partial differential equations using integral transforms in boundary value problems (CO5)

Mapping of Course Outcomes with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			2
CO2	3	2		2	2
CO3	3	2		2	2
CO4	3	2		2	2

1: Low 2: Moderate 3: High

Mapping of Course Outcomes with Question paper

	Q1 (10 marks)	Q2 (10 marks)	Q3 (10 marks)	Q4 (10 marks)	Q4 (10 marks)	Q4 (10 marks)
CO1	2	3	1	1		
CO2	2	3	1	2	1	1
CO3	1	2	2	3	2	3
CO4	2	1	3	2	3	3

Foundation of Quantum Mechanics

The course introduces the concepts and postulates of **wave mechanics** to the formulation of quantum mechanics, **the matrix formulation**, the development of Dirac notation, the operators for quantum angular momenta. The one-dimensional Schrodinger equation is discussed at length and the problems addressed are Particle in a box, harmonic oscillator, unbound states, potential well, two particle problem, radial equation and complete solution of the hydrogen atom problem using spherical harmonics and other special functions.

Course Outcomes:

At the end of the course, the learner is able to

1. Understand the basic principles of Quantum mechanics and the need for its formalism (CO1)
2. Understand the Uncertainty Principle and formulation of Schrodinger equation (CO2)
3. Understand the importance of Dirac formalism, vector spaces and apply the same in solving problems of potential barrier, square well potential (CO3)
4. Apply the techniques of solving differential equations using various special functions as they appear in the solution of Schrodinger equation for Hydrogen atom problem (CO4)
5. Solve the various boundary value and potential problems using the techniques of quantum mechanics (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			3
CO2	3	2			2
CO3	3	2		2	2
CO4	3	2		2	2

1: Low 2: Moderate 3: High

Mapping of Course Outcomes with Question paper

	Q1 (10 marks)	Q2 (10 marks)	Q3 (10 marks)	Q4 (10 marks)	Q4 (10 marks)	Q4 (10 marks)
CO1	2	3	1	1		
CO2	2	3	1	2	1	1
CO3	1	2	2	3	2	3
CO4	2	1	3	2	3	3

Fundamental of Material Science

Course Objective:

The advancement of civilization has historically depended on the improvement of materials to work with. The materials scenario is fast changing and development of new materials are being reported very rapidly. These development are taking place so as to meet the ever-increasing demand for newer and better quality products, greater efficiency, increased service life and stringent reliability requirements. In view of these requirements of today's technological society, a proper exposure to students to the field of material science is a must.

This course on Fundamental of Material Science is primarily meant to provide the students with strong foundation for better understanding of the structure and property relationship in materials, understanding mechanical behavior such as fatigue, fracture, creep, deformation, corrosion behavior and processing and performance of materials, engineering and applications of materials etc. Details of experimental techniques used for identification and characterization purpose as well as those techniques which are used for mechanical testing of various materials will be extensively taught to the students. By solving several numerical exercise during the course will help the students in their learning and understanding process.

Course Outcome:

At the end of the course, the learner is able to

1. Correlate the atomic structure of various materials with the acquired properties required for the various applications. (CO1)
2. Identify the various crystal system created by arrangements of atoms and ions in soilds, and explain the basic building blocks of solid. (CO2)
3. Classify the different defects in the materials produce during the manufacturing process and explain the role of these defects on the different properties of materials. (CO3)
4. Describe the principles of characterization techniques used to investigate the materials from atomic to macroscopic level. (CO4)
5. Analyze the capability of each materials and estimate its functioning and lifetime for any particular applications. (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			2	3
CO2	3	2		2	3
CO3	3	2	2	2	3
CO4	3	2	3	3	1

1: Low 2: Moderate 3: High

Mapping of Course Outcomes with Question paper

	Q1 (10 marks)	Q2 (10 marks)	Q3 (10 marks)	Q4 (10 marks)	Q4 (10 marks)	Q4 (10 marks)
CO1	2	3	1	1		

CO2	2	3	1	2	1	1
CO3	1	2	2	3	2	3
CO4	2	1	3	2	3	3

CHEMISTRY OF MATERIALS

Course Objectives: Study of chemistry advanced material synthesis and material characterisation. It gives connections between the structure and properties of solids, including theory and methods you can apply to the development of new materials with particular desired properties, and learn to conduct chemical analyses and characterisation of the physical properties of solids.

Course Outcomes:

CO1: This course aims at acquainting the students the knowledge of the factors affecting glass formation various thermodynamic, kinetic factors controlling the designing of glass materials, important compositions and different properties.

CO2: A complete packet of knowledge of the preparation of smart materials and their applications as nano drug delivery agents and energy storage materials.

CO3: The aim is to help the students to understand the basics of glass formation from different materials along with different kinetic and thermodynamic aspects discussing the applications also. Smart materials will be introduced while discussing different electrical and magnetic properties

CO4: The aim is to help the students to understand the basics of glass formation from different materials along with different kinetic and thermodynamic aspects discussing the applications also. Smart materials will be introduced while discussing different electrical and magnetic properties

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			2	3
CO2	3	2		2	3
CO3	3	2	2	2	3
CO4	3	2	3	3	1

1: Low 2: Moderate 3: High

Mapping of Course Outcomes with Question paper

	Q1 (10 marks)	Q2 (10 marks)	Q3 (10 marks)	Q4 (10 marks)	Q4 (10 marks)	Q4 (10 marks)
CO1	2	3	1	1		
CO2	2	3	1	2	1	1
CO3	1	2	2	3	2	3
CO4	2	1	3	2	3	3

Solid State Devices

Course Objectives:

1. Develop strong background in semiconductor physics.
2. Use this background to understand the operation of basic two-terminal and three-terminal semiconductor devices.

Course Outcomes:

CO1: The differences between metals, insulators, and semiconductors and origin of their properties based on the crystal structures of materials.

CO2: Intrinsic and extrinsic semiconductors and role of doping in engineering the properties of semiconductor structures.

CO3: The fabrication process of silicon wafers, starting from silica.

CO4: Generation and recombination of charge carriers in semiconductors under electrical, optical and thermal excitation, and transport of these carriers under an electric field.

Mapping of Course Outcomes with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			2	3
CO2	3	2		2	3
CO3	3	2	2	2	3
CO4	3	2	3	3	1

1: Low 2: Moderate 3: High

Mapping of Course Outcomes with Question paper

	Q1 (10 marks)	Q2 (10 marks)	Q3 (10 marks)	Q4 (10 marks)	Q4 (10 marks)
CO1	2	3	1	1	
CO2	2	3	1	2	1
CO3	1	2	2	3	2
CO4	2	1	3	2	3

Modeling of Materials

Course Objectives: Upon completion of this course students are expected to: i) be familiar with a variety materials modeling methods including electronic structure, molecular dynamics, Monte Carlo, finite differences, finite elements, and microstructure evolution methods ii) be able to design and perform simple computer experiments using techniques appropriate for the problem at hand, iii) recognize the approximations and level of accuracy to be expected from each modeling technique, and iv) be able to critically read the scientific literature on computational modeling and simulation of materials.

Course Outcomes:
CO1: An ability to apply knowledge of mathematics, science, and engineering to problems in materials engineering.
CO2: An ability to identify, formulate, and solve engineering problems, particularly in the context of materials selection and design.
CO3: An ability to exhibit effective oral and written communication skills.
CO4: An ability to use the techniques, skills, and experimental, computational and data analysis tools necessary for materials engineering practice.

Mapping of Course Outcomes with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			2	3
CO2	3	2		2	3
CO3	3	2	2	2	3
CO4	3	2	3	3	1

1: Low 2: Moderate 3: High

Mapping of Course Outcomes with Question paper

	Q1 (10 marks)	Q2 (10 marks)	Q3 (10 marks)	Q4 (10 marks)	Q4 (10 marks)
CO1	2	3	1	1	
CO2	2	3	1	2	1
CO3	1	2	2	3	2
CO4	2	1	3	2	3

Syllabus

MS-101: Applied Mathematics (60 lectures, 4 credits)

Unit-1: Vector Calculus

Review of vector addition and multiplication – dot product, cross product, scalar and vector triple products, concept of vector derivative (del operator) - gradient, divergence, curl and Laplacian operators, convective derivative and Maxwell's equations as examples

Unit-2 Differential Equations

Ordinary differential equations (ODE), first order ODE, second and higher order homogenous linear ODE, ODE with inhomogeneous term, methods of solution, Differential Equations: Frobenius method, series solutions, Legendre, Hermite and Laguerre polynomials, Bessel equations, Partial differential equations, separation of variables, wave equation and heat conduction equation. Green's functions in one dimension.

Unit 3: Matrices and Integral Transforms

Matrices, revision of matrix addition and multiplication, algebraic properties of matrices, their trace and their determinant, minimal concepts of linear algebra, the matrix eigenvalue problem, diagonalisation of matrices
Fourier series (basic introduction only), Fourier transform and properties, applications of Fourier transform, Laplace transform and properties, applications of Laplace transform

Unit-4 Complex Numbers:

Complex Variables, Limits, Continuity, Derivatives, Cauchy-Riemann Equations, Analytic functions, Harmonic functions, Elementary functions: Exponential and Trigonometric, Taylor and Laurent series, Residues, Residue theorem, Principal part of the functions, Residues at poles, zeroes and poles of order m, Contour Integrals, Evaluation of improper real integrals, improper integral involving Sines and Cosines,

References:

1. S.D.Joglekar, Mathematical Physics: The Basics, Universities Press 2005
2. S. D.Joglekar, Mathematical Physics: Advanced Topics, CRC Press 2007
3. M.L. Boas, Mathematical methods in the Physical Sciences, Wiley India 2006

Additional references.

1. G. Arfken: Mathematical Methods for Physicists, Academic Press
2. A.K. Ghatak, I.C. Goyal and S.J. Chua, Mathematical Physics, McMillan
3. A.C. Bajpai, L.R. Mustoe and D. Walker, Advanced Engineering Mathematics, John Wiley
4. E. Butkov, Mathematical Methods, Addison-Wesley
5. J. Mathews and R.L. Walker, Mathematical Methods of physics
6. P. Dennery and A. Krzywicki , Mathematics for physicists

MS-102:Quantum Mechanics-I (60 lectures, 4 credits)

Unit-1: Theory:

Review of concepts: Analysis of the double-slit particle diffraction experiment; the de Broglie hypothesis; Heisenberg's uncertainty principle; probability waves. Postulates of QM: Observables and operators; measurements; the state function and expectation values; the time-dependent Schrodinger equation; time development of state functions; solution to the initial value problem. Superposition and Commutation: The superposition principle; commutator relations; their connection to the uncertainty principle; degeneracy; complete sets of commuting observables. Time development of state functions and expectation values; conservation of energy, linear momentum and angular momentum; parity.

Unit-2: Formalism:

Dirac notation; Hilbert space; Hermitian operators and their properties. Matrix mechanics: Basis and representations; matrix properties; unitary and similarity transformations; the energy representation. Schrodinger, Heisenberg and Interaction pictures.

Unit-3: Schrodinger equation solutions:-1

One-dimensional Problems: General properties of one-dimensional Schrodinger equation. Particle in a box. Harmonic oscillator. Unbound states; one-dimensional barrier problems. Finite potential well.

Unit-4: Schrodinger equation solutions:-2

Three-dimensional Problems: Orbital angular momentum operators in cartesian and spherical polar coordinates, commutation and uncertainty relations, spherical harmonics. Two-particle problem - coordinates relative to the centre of mass; radial equation for a spherically symmetric central potential. Hydrogen atom, eigenvalues and radial eigenfunctions, degeneracy, probability distribution.

Texts:

1. Richard Liboff, Introductory Quantum Mechanics, 4th ed., 2003. (RL)
2. DJ Griffiths, Introduction to Quantum Mechanics, 1995. (DG)
3. A Ghatak & S Lokanathan, Quantum Mechanics: Theory & Applications. 5thed., 2004. (GL)

Additional References:

W Greiner, Quantum Mechanics: An Introduction, 4th. ed., 2004.
R Shankar, Principles of Quantum Mechanics, 2nd ed., 1994.
SN Biswas, Quantum Mechanics, 1998.

MS-103: Fundamentals of Materials Science (60 lectures, 4 credits)

Unit 1:

Crystallography Crystal Structures and Crystal Geometry, The Space Lattice andUnitCells, Crystal Systems and Bravais Lattices, Principal Metallic Crystal Structures, Atom Positions in Cubic Unit Cells, Directions in Cubic Unit Cells, Miller Indices For Crystallographic Planes In Cubic Unit Cells, Crystallographic Planes and Directions In Hexagonal Unit Cells, Comparisonof FCC,HCP, and BCC Crystal Structures, Volume, Planar, and Linear

DensityUnit Cell Calculations, Polymorphism or Allotropy, Crystal Structure Analysis, Point group, Space group, Crystalline Imperfections, point defects, dislocations and stacking faults.

Unit 2:

Metallurgy Solidification of Metals, Solidification of Single Crystals, Metallic SolidSolutions, Rate Processes in Solids, Diffusion In Solids, Industrial Applicationsof Diffusion Processes, Effect of Temperature on Diffusion In Solids. PhaseDiagrams, Phase Diagrams of Pure Substances, Gibbs Phase Rule, BinaryIsomorphous Alloy Systems, The Lever Rule, NonequilibriumSolidificationof Alloys, Binary Eutectic Alloy Systems, Binary Peritectic Alloy Systems, BinaryMonotectic Systems, Invariant Reactions, Phase Diagrams With IntermediatePhases and Compounds, Ternary Phase Diagrams

Unit 3:

Mechanical Properties of Solids Mechanical Properties of Metals, the Processing of Metals and Alloys, Stress and Strain In Metals, The Tensile Test and The EngineeringStress- Strain Diagram, Hardness and Hardness Testing, Plastic Deformationof Metal Single Crystals, Plastic Deformation of Polycrystalline Metals, Solid-Solution Strengthening of Metals, Recovery and Recrystallizationof Plastically Deformed. Metals, Fracture of Metals, Fatigue of Metals, Creepand Stress Rupture of Metals. Tribology: wear of metals–mechanisms, factorsinfluencing wear, wear resistance-protection against wear

Unit 4:

Degradation of Metals Corrosion, Electrochemical Corrosion of Metals, Galvanic Cells, Corrosion Rates (Kinetics), Types of Corrosion, Oxidation of Metals, Corrosion Control. Prevention of degradation: Alloying environment, environmentconditioning, design modification, Cathodic and anodic protection, organicand inorganic coating, inhibitors and passivators, Wear resistant coating.

Reference books:

Materials Science and Engineering, W. Smith. J. Hashemi, R. Prakash 4th edition.

1. Materials Science and Engineering, W. Smith. J. Hashemi, R. Prakash 5th edition.
2. Fundamentals of Materials Science, The Microstructure–Property Relationship Using Metals as Model Systems by Eric J. Mittemeijer
3. Material Science and Engineering by William Callister
4. Exploring the Marvelous Materials that Shape Our Man-Made World by Mark Miodownik
5. The New Science of Strong Materials by JE Gordon
6. The Materials The World is Made of by Ivan Amato
7. Introduction to Materials Science for Engineers by James Shackelford
8. Foundations of Materials Science and Engineering by William Smith
9. The Science and Engineering of Materials by Donald Askeland and Wendelin Wright
10. Material Science and Metallurgy by OP Khanna
11. Ceramic Materials by C. Barry Carter and M. Grant Norton
12. Thermodynamics in Material Science by Robert Dehoff

MS-104-Practicals

1. Susceptibility measurement by Guoy's balance method
2. Study of Hall effect and estimation of Hall coefficient R, carrier density (n) and carier mobility of Semiconductor material
3. Measurement of Magneto resistance of Bi specimen
4. Michelson Interferometer
5. Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)
6. Ultrasonic Interferometer – Young's modulus and elastic constant of solids
7. Study of Thermal properties of given crystal (specific heat, thermal expansion, thermal conductivity)
8. Study of variation of magnetic properties with composition of a ferrite Specimen using BH loop tracer
9. Study of colour centres and thermo luminance of alkali halides (Metal Oxides)
10. Resistivity & Energy band gap by four probe method

MS-511: Chemistry of Materials

Unit-1:

What is Materials Chemistry?Fundamental Principles that Underlie Materials Chemistry, General Background to Materials Synthesis and Isolation, Chemistry of Representative Elements, Characterization

Unit-2:Types of Materials-1

Small Molecules in Solids, Porous Solids, Ceramics and Inorganic Glasses, Polymers: Fundamental Aspects, Polymer Morphology and Fabrication, Carbon-Based Materials, Metals and Alloys, Superconductors

Unit-3: Types of Materials-2:

Semiconductors, Topological Insultors, Smart Materials, Shape memory alloys, High temperature ceramics, Amorphous Materials, Composites Materials, 0D, 1D, 2D Materials

Unit-4:Materials in Advanced Technology

Semiconductor Basics, Photolithography, Semiconductor Devices, Optical and Photonic Devices, Materials for Energy Generation and Storage, Membranes, Surface Science, Biomedical Materials, Miniaturization in Materials Science

References:

1. Introduction to Materials Chemistry, 2nd Edition, Harry R. Allcock, ISBN:978-1-119-34725-5, October 2019, Wiley Publishers.
2. Materials Chemistry, Bradley D. Fahlman, 2018, springer.
3. Chemistry of Materials, Meghann Murray and Mark Anthony Benvenuto, Publisher: De Gruyter, 2021
4. Solid state Materials Chemistry, Patrick M. Woodward, Pavel Karen, John Evans, Thomas Vogt, Cambridge University Press, 2021

MS-512: Solid State Devices (60 lectures, 4 credits):

Unit-1:

Semiconductor Physics: Classification of Semiconductors; Crystal structure with examples of Si, Ge & GaAs semiconductors; Energy band structure of Si, Ge & GaAs; Extrinsic and compensated Semiconductors; Temperature dependence of Fermi-energy and carrier concentration. Drift, diffusion and injection of carriers; Carrier generation and recombination processes-Direct recombination, Indirect recombination, Surface recombination, Auger recombination; Applications of continuity equation-Steady state injection from one side, Minority carriers at surface, Haynes Shockley experiment, High field effects. Hall effect; Four – point probe resistivity measurement; Carrier life time measurement by light pulse technique. Introduction to amorphous semiconductors, Growth of semiconductor crystals.

Unit-2:

Devices I: p-n junction : Fabrication of p-n junction by diffusion and ion implantation; Abrupt and linearly graded junctions; Thermal equilibrium conditions; Depletion regions; Depletion capacitance, Capacitance – voltage (C-V) characteristics, Evaluation of impurity distribution, Varactor; Ideal and Practical Current-voltage (I-V) characteristics; Tunneling and avalanche reverse junction break down mechanisms; Minority carrier storage, diffusion capacitance, transient behavior; Ideality factor and carrier concentration measurements; Carrier life time measurement by reverse recovery of junction diode;; p-i-n diode; Tunnel diode, Introduction to p-n junction solar cell and semiconductor laser diode.

Unit-3:

Devices II: Metal – Semiconductor Contacts: Schottky barrier – Energy band relation, Capacitance-voltage (C-V) characteristics, Current-voltage (I-V) characteristics; Ideality factor, Barrier height and carrier concentration measurements; Ohmic contacts. Bipolar Junction Transistor (BJT): Static Characteristics; Frequency Response and Switching. Semiconductor heterojunctions, Heterojunction bipolar transistors, Quantum well structures.

Unit-4:

Devices III: Metal-semiconductor field effect transistor (MESFET)- Device structure, Principles of operation, Current voltage (I-V) characteristics, High frequency performance. Modulation doped field effect transistor (MODFET); Introduction to ideal MOS device; MOSFET fundamentals, Measurement of mobility, channel conductance etc. from I_{ds} vs, V_{ds} and I_{ds} vs V_g characteristics. Introduction to Integrated circuits.

Main References:

1. S.M. Sze; Semiconductor Devices: Physics and Technology, 2nd edition, John Wiley, New York, 2002.
2. B.G. Streetman and S. Benerjee; Solid State Electronic Devices, 5th edition, Prentice Hall of India, NJ, 2000.
3. W.R. Runyan; Semiconductor Measurements and Instrumentation, McGraw Hill, Tokyo, 1975.
4. Adir Bar-Lev: Semiconductors and Electronic devices, 2nd edition, Prentice Hall, Englewood Cliffs, N.J., 1984.

Additional References:

1. Jasprit Singh; Semiconductor Devices: Basic Principles, John Wiley, New York, 2001.
2. Donald A. Neamen; Semiconductor Physics and Devices: Basic Principles, 3rd edition, Tata McGraw-Hill, New Delhi, 2002.

3. M. Shur; Physics of Semiconductor Devices, Prentice Hall of India, New Delhi, 1995.

4. Pallab Bhattacharya; Semiconductor Optoelectronic Devices, Prentice Hall of India, New Delhi, 1995.

5. S.M. Sze; Physics of Semiconductor Devices, 2nd edition, Wiley Eastern Ltd., New Delhi, 1985.

MS-513:-Modeling of Materials

Unit–I

Basic Concepts and Theoretical Background: Introduction and basic concepts: Theoretical background, basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, Independent electron approximations, periodic solids and electron bands, structures of crystals: lattice + basis, the reciprocal lattice and Brillouin zone, excitations and the Bloch theorem. The quantum theory of bonding: The Hamiltonian formulation, Dirac notation, electronic wave function, Schrödinger equation.

Unit–2

Quantum Mechanics of Materials : Central field approximation, Hamiltonian of the solid, Born-Oppenheimer approximation, hydrogen atom and molecule. Hartree-Fock method: Coulomb and exchange operator, Fock operator, the HartreeFock Hamiltonian, basis set, charge density, the self-consistent field (SCF) procedure, expectation value. Density functional theory: Exact formulation, approximations, choice of basis functions, essential machinery of a place-wave DFT code, energy minimization and dynamics. Semi-empirical tight binding methods: Linear combination of atomic orbitals (LCAO), Hamiltonian and overlap matrices, Slater-Koster parameters for two-center integral, tight binding to empirical atomistic models.

Unit–3

Molecular Statics :- The potential energy landscapes. Energy minimization: Generic nonlinear minimization, steepest descent, line minimization, conjugate method, Newton-Raphson method.Saddle points and transition paths: Nudged elastic band method Implementing molecular statics: Neighbor list, periodic boundary condition, applying stress and pressure, boundary conditions on atoms.Application to crystals and crystalline defects: Cohesive energy of an infinite crystal, crystal defects (vacancies, surfaces, interfaces, dislocations).

Unit–4

Modelling and Simulations of Materials:

Model systems and interatomic potentials, Molecular Dynamics: Equations of motion for atomic systems, the basic machinery and finite difference methods, time integration algorithm, starting a simulation, simulation of microcanonical (NVE) and canonical ensemble (NVT), controlling the system (temperature, pressure), thermostats and barostats, equilibration, running, measuring and analyzing MD simulation data, measurement of statistical quantities, estimating errors.

References:

1. Condensed Matter in a Nutshell, G. D. Mahan, Princeton University Press, Princeton and Oxford (2011).
2. Modern Quantum Chemistry – Introduction to Advanced Electronics Structure Theory,
3. A Szabo and N. S. Oslund, Dover Publications Inc., Mineola, New York, (1989).
4. Electronic Structure Calculations for Solids and Molecules – Theory and Computational
5. Methods, Jorge Kohanoff, Cambridge University Press, 1 edition (2006).
6. Modelling materials – Continuum, Atomistic, Multiscale Techniques, E. B. Tadmor and
7. E. Miller, Cambridge University Press, New York (2011).
8. Computer Simulation of Liquids, M. P. Allen and D. J. Tildesley, Clarendon Press Oxford, (1991). Understanding Molecular Simulations, D. Frenkel and B. Smit, Academic Press, (2002).

MS-514: Practicals

1. Rockwell and Brinnels Hardness testing of Materials
2. Studying the corrosion properties of coatings.
3. Determine Dielectric Constant of Ferroelectric Material using LCR bridge
4. Resistivity of Ge sample by van der Pauw method at different temp and determination of band gap
5. Grain Size measurement Ferrous alloys and Non-ferrous Alloys using optical microscope
6. Image analysis, finding defects, particle size analysis from SEM and TEM images
7. Investigating Crystal structure and miller indices of the given XRD Pattern
8. Non-Destructive Technique – Ultrasonic flaw detector
9. Laser Experiments – Wavelength and Particle Size Determination
10. Refractive index of Material using He-Ne laser
11. Thermo-emf of bulk samples of metals (aluminium or copper)

Electives

MS-505A:Materials and their Applications :
Unit 1:

Engineering Alloys, Production of Iron and Steel, The Iron-Iron Carbide Phase Diagram, Heat Treatment of Plain-Carbon Steels, Low-Alloy Steels, Aluminum Alloys, Copper Alloys, Stainless Steels, Cast Irons, Magnesium, Titanium, and Nickel Alloys,

Unit 2:

Corrosion, Electrochemical Corrosion of Metals, Galvanic Cells, Corrosion Rates (Kinetics), Types of Corrosion, Oxidation of Metals, Corrosion Control

Unit 3:

Polymeric Materials, Polymerization Reactions, Industrial Polymerization Methods, Crystallinity and Stereoisomerism In Some Thermoplastics, Processing of Plastic Materials, General-Purpose Thermoplastics, Engineering Thermoplastics, Thermosetting Plastics (Thermosets), Elastomers (Rubbers), Deformation and Strengthening of Plastic Materials, Creep and Fracture of Polymeric Materials.

Unit 4:

Ceramic Materials, Simple Ceramic Crystal Structures, Silicate Structures, Processing of Ceramics, Traditional and Technical Ceramics, Electrical Properties of Ceramics, Mechanical Properties of Ceramics, Thermal Properties of Ceramics, Glasses. Composite Materials, Fibers for Reinforced-Plastic Composite Materials, Fiber-Reinforced-Plastic Composite Materials, Open-Mold Processes for Fiber-Reinforced-Plastic Composite Materials, Closed-Mold Processes for Fiber-Reinforced-Plastic Composite Materials, Concrete, Asphalt and .Asphalt Mixes, Wood, Sandwich Structures.

Reference:

1. William F Smith, Javad Hashemi, Ravi Prakash, Materials Science and Engineering, Tata-McGraw Hill, 4th Edition.

505B:Materials Processing Techniques

Unit I – Vacuum Techniques

Fundamental processes at low pressures, Mean Free Path, Time to form monolayer, Number density, Materials used at low pressure, vapour pressure Impingement rate, Flow of gases, Production of low pressures; High Vacuum Pumps and systems, Ultra High Vacuum Pumps and System, Measurement of pressure, Leak detections

Unit 2--Thin film deposition techniques

Preparation of Thin Films: Thermal evaporation, e-beam deposition, Cathode Sputtering, DC sputtering, Magentron sputtering, Chemical vapor Deposition, Laser Ablation, Molecular Beam epitaxy, electro-plating, sol-gel method (Spin and Dip coatings), Langmur-Blochet Films

Unit 3 Crystal Growth phenomena

The historical development of crystal growth – significance of single crystals - the chemical physics of crystal growth Crystal growth: Phase equilibria and Crystallization Techniques, phase diagrams and solubility curves, Kinetics of Nucleation, Rate equation, Heterogeneous and secondary nucleation, Crystal surfaces, growth mechanisms, mass transport, crystal morphology,, influence of supersaturation, temperature, solvents, impurities; Polymorphism – phase transition and kinetics.

Unit 4: Crystal Growth Technology

Silicon, Compound semiconductors, CdTe, CdZnTe, Czochralski technique, Bridgman technique, Float zone Process, Liquid Phase expitaxy, Molecular Beam epitaxy. Growth of Oxide & Halide crystals- Techniques and applications,

References:

A User's Guide to Vacuum Technology:by John F. O'Hanlon, First published:20 June 2003, Print ISBN:9780471270522 |Online ISBN:9780471467168 |DOI:10.1002/0471467162,

Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy, 2nd Edition, https://doi.org/10.1142/5172, August 2003. by Ivan V Markov (*Bulgarian Academy of Sciences, Bulgaria*),

Handbook of Thin Film Deposition: 4th Edition - February 23, 2018, Editors: Krishna Seshan, Dominic Schepis, Paperback ISBN: 9780128123119

MS-505C:Metallurgy:

Unit-1: Atomic Structure and chemical Bonding: Quantum mechanical approach, Schrödinger wave equation, wave function, Quantum state, Periodic Table, electronic configuration and atomic structure. Bonding in solids, different types of bonds, Bond energy, effect of bonding on material properties.

Unit-2: Structure of Solids : The crystalline and the noncrystalline states – Metals and Alloys, Ceramics, semiconductors and polymers; Crystal structure – concept of lattice and crystal, Translational periodicity and symmetry, crystal systems, space lattice, representation of atomic position, lattice directions and lattice planes in cubic and hexagonal systems; atomic packing, voids in FCC, BCC and HCP crystals; crystal imperfections– point defect, line defect, surface defect and volume defect; equilibrium concentration of point defect. (12) Solidification of metals and alloys including Rapid Solidification Technology.

Unit-3:Phase diagrams:

The phase rule, single component system. Binary phase diagrams with reference to a few important metallic systems, Corrosion and oxidation of materials: The principles of corrosion; Protection against corrosion; Mechanism of oxidation; Oxidation resistant materials.

Unit-4:

Sources of nonferrous metals Principles of metals extraction, Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, electro-chemistry, General methods of extraction, (Pyro-metallurgy– calcinations, roasting (predominance area diagram) and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy– electrolysis and electro-refining), General methods of refining, (Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk).

References:

1. Materials Science and Engineering: A first course – V. Raghavan, PHI Learning Pvt. Ltd., 2004.
2. Introduction to Metallurgy - A.H. Cottrell, Arnold, 1968.
3. Extraction of nonferrous metals, H.S. Ray, R.Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007).
4. H.S. Ray and A. Ghosh, Principles of extractive metallurgy,Wiley Eastern Ltd., New Delhi (1991)

MS505D:Thermodynamics of Materials

Unit 1:

Review: Concept of temperature, Zeroth law of thermodynamics, types of processes, PV diagram as a tool for analysis; Concepts of internal energy, work and heat, First law of thermodynamics, thermodynamic state of a system, specific heat Second law of thermodynamics, efficiency of a thermodynamic cycle, irreversibility, concept of entropy, TS diagram and it use Thermodynamic potentials: comparative analysis of Enthalpy, Helmholtz free energy and Gibbs free energy, first order phase transitions and the Clausius-Clapeyron equation

Unit 2:

Properties of Pure Substances: Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, equations of state, compressibility chart. Thermodynamic Relations, T-ds relations, Maxwell equations, Liquefaction of gases: Joule-Thomson effect, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron equation.

Unit 3:

Equilibrium Concept in Thermodynamics Unary, binary and multicomponent Systems, phase equilibria, evolution of phase diagrams, metastable phase diagrams, calculation of phase diagrams, thermodynamics of defects. solution models

Unit 4:

Thermodynamics of Phase transformation and Heterogeneous Systems: Melting and solidification, precipitation, eutectoid, massive, spinodal, martensitic, order disorder transformations and glass transition. First and second order transitions..Equilibrium Constants and Ellingham diagrams

References:

1. M. Modell and R.C. Reid, Thermodynamics and its Applications, Prentice-Hall, Englewood Cliffs, New Jersey, 1983.
2. H.B. Callen, Thermodynamics and an Introduction to Thermostatics, Jonh Wiley & Sons, New York, 1985.
3. R.T. DeHoff, Thermodynamics in Materials Science, McGraw-Hill, Singapore
4. Thermodynamics of Solids: R.A. Swalin
5. Phase Transformations in Metals and Alloys: D.A. Porter and K.E. Easterling

MS-515A:-Plastics

Unit-1:

Introduction to Polymeric Materials: Thermoplastics, Thermosets, commodity, Engineering & High-performance plastics. Classification of polymeric materials based on applications Structure of Plastics: Molecules Crystallinity, Effect of Crystallinity on properties cross linked plastics Linear, Branched and cross linked structures in polymers.

Unit-2:

Commodity Thermoplastics-I Preparation properties and applications of Polyolefine-Polyethylene, LDPE LLDPE, HDPE, HMWHDPE, UHMWHDPE Crosslinked polyethylene, Chlorinated polyethylene, Polypropylene, Homo & Co polymer.

Unit-3:

Commodity Thermoplastics-II Preparation - properties - and applications of Vinyl plastics Polyvinyl chloride, C-PVC, Polyvinyl Acetate, Polyvinylidene chloride, Polyvinyl alcohol, Polystyrene,

Unit-4:

General Purpose Thermosets Preparation properties and applications of: Phenol formaldehyde (PF) ,Amino plastics: Urea formaldehyde (UF) Melamine formaldehyde (MF), Unsaturated polyesters, Alkyd resins. Engineering and Speciality Thermosets Preparation - properties - and applications of: Epoxy Resins, Polyurethanes (PU) Silicone polymers.

Text Books:

1. J.A. Brydson, “Plastics Materials”, Butterworth- Heinemann - Oxford 7 th Ed., 2001.

2. Feldman. D and Barbalata. A, “Synthetic Polymers”, Chapman Hall, 1996.

Reference Books:

1. V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, “Polymer Science”, New Age International (P) Ltd Publishers 2nd edition, 2015.

2. Olagoke Olabisi, “Hand Book of Thermoplastics”, Marcel Decker Inc., 1997. 3. K.J. Saunders, “Organic Polymer chemistry”, Chapman & Hall, 1988. 4. Irvin. I. Rubin, “Hand Book of Plastic Materials and Technology”, Wiley Interscience, 1990

MS-515B:-Aerospace Materials

Unit-1:

Mechanical behavior of Materials:Introduction to aerospace materials and their classification, Linear and non-linear elastic properties-Stress and Strain Curves-Yielding and strain Hardening, Toughness- Modules of resilience- Bauchinger's effect-Effect of notches-Testing and flaw detection of materials and components,

Unit-2:

Aluminium and its alloys: Types and identification. Properties- Castings-Heat treatment processes –Surface treatments. Magnesium and its alloys: Cast and Wrought alloys-Aircraft application, features specification, fabrication problems, Titanium and its alloys:Applications, machining, forming, welding and heat treatment, Copper Alloys. plastics & rubber in aircraft, Introduction to glass & carbon composite.

Unit-3:

Ferrous materials in aircraft construction: Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications. Maraging Steels: Properties and Applications. Super Alloys: Use -Nickel base-Cobalt base- Iron base -Forging and Casting of Super alloys-Welding, Heat treatment. Ceramics and Composites: Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes and its aerospace applications involved in metal matrix composites, polymer composites.

Unit-4:

High Temperature Materials Characterization: Classification, production and characteristics, Methods and testing, Determination of mechanical and thermal properties of materials at elevated temperatures, Application of these materials in Thermal protection systems of Aerospace vehicles, High temperature material characterization.

Textbook/s

1. Aircraft Material and Processes Titterton G F Lienhard V English Book Store, New Delhi 5th Ed.,1998
2. Advanced Aerospace Materials H Buhl Springer, Berlin 1992

Reference Books

1. Aerospace material Balram Gupta S Chand & Co 2009.
2. Materials for Missiles and Space ParkerER Mc Graw-Hill 1963.

MS-515C:-Liquid Crystals

Unit-I: Introduction to the Science and technology of Liquid Crystal.

Types and Classification of liquid crystals, Nature's of Anisotropic Liquid Crystals. Calamtic liquid crystal, Discotic Liquid crystal, Polymer liquid crystals, Chiral liquid crystal, ,membranes colloidal system. Display Technologies Overview.

Unit-II: **Theoretical Insights**

Nature of phase transitions and critical phenomenon in liquid crystals, Maier-Saupe, Landau de gennes theory, Van der Walls theories. Continuum theory: Curvature elasticity in nematic smectic A phases, Distortions due to magnetic and electric fields, Magnetic coherence length, Freedeicksz transitions. Onsager's mean field theory,

Unit-III:Merits of LCs

Dynamical properties of Nematic, equations of nemato-dynamics, laminar flow, Fluid vs. solid membranes, energy and elasticity, surface tension, viscoelasticity, Molecular motions. LC in electric and magnetic fields, light and liquid crystals, Mechanical, Optical Properties: Cholesteric, Ferroelectric, Antiferroelectric, Polymer dispersed liquid crystals, Elastomer.

Unit IV:*Characterization Techniques and Applications*

Techniques used for Identification and characterizations of Liquid crystal phases, Lyotropic liquid crystals and biological membrane,: Survey over flat panel technologies. Liquid crystal displays, plasma displays .Applications of liquid crystals.

References:

1. Introduction to liquid crystals: Physics and Chemistry.: Peter J Collings and Michael Hird Taylor and Francis,1997.
2. Liquid crystal: The fourth state of matter.Frankin D saeva. Wiely publication.
3. Liquid Crystals: S Chandrsekhar, Cambridge University Press, 2nd edition, 1992.
4. The physics of liquid crystals: P G de Gennes and J Prost, Oxford University
5. Ferroelectric liquid crystals: Principle properties and Applications: Gooby et a.l Gordon & Breach Publishing Group, 1991
6. Thermotropic liquid crystals: Fundamental Vertogen and de jeu.
7. Polymer materials-Macroscopic properties and molecular Interpretations. Jean-Louis Halary,Lucien monnerie.published by Wiley.
8. The Optic of Thermotropic Liquid Crystals.Steve Elston and Roy Sambles.
9. Textures of Liquid Crystals. Detrich Demus, Lothar Richter.Newyork 1978
10. Textures of Liquid Crystals- Ingo Dierking John Wiley & Sons, 08-May-2006 - Technology & Engineering..
11. .Liquid Crystal: Experimental Study of Physical Properties and Phase Transitions Satyen Kumar, Cambridge University Press, 2001
12. Physical Properties of Liquid Crystals: George W. Gray, Volkmar Vill, Hans W. Spiess, Dietrich Demus, John W. Goodby John Wiley & Sons, - 2009 Technology & Engineering.
13. Handbook of Liquid Crystals, High Molecular Weight Liquid Crystal Dietrich Demus, John W. Goodby, George W. Gray, Hans W. Spiess, Volkmar Vills –
14. Principles of condensed matter physics – P.M. Chalkin and T.C. Lubensky.

15. Collidal Dispersions-W.B Russel , Cambridge University Press. New York (1989)

MS-515D: Semiconductors Materials

Unit 1: Transport Properties of Semiconductors:

The Boltzmann transport equation and its solutions for (i) Electric field alone (ii) Electric and Magnetic fields together. Hall Effect and Magneto resistance (van der Ziel). Scattering mechanism and Relaxation time concept, Transport in high electric fields, hot electrons (Wang), transferred electron effects (Smith). Transport in 2-Dimentional quantum well - (a) High field effects (i) Landau levels, (ii) Shubnikov de Hass effect, (iii) Quantum Hall effect (b) Perpendicular transport - Resonant Tunneling.

Unit 2: Optical Properties of Semiconductors:

Optical properties of Semiconductors: Fundamental absorption, Exciton absorption, Impurity absorption, Free carrier absorption. Radiative recombination. Photoconductivity. Surface recombination (Smith). Optical processes in quantum wells: Interband transitions in quantum wells, Intraband transitions

Unit 3: Amorphous & Organic Semiconductors:

Electronic density of states, localization, Transport properties, Optical properties, Hydrogenization of amorphous silicon, Si:H fields effect transistors-design, fabrication and characteristics. Organic semiconductors, Polymers.

Unit 4: Advanced Electronic Materials:

Photovoltaics Fundamentals & Materials, Spintronics materials, Dilute magnetic semiconductors, Magnetites, Giant-magnetoresistance. Composites, Glasses, Ceramics, Liquid crystals, Quasicrystals. Quantum wells, wires and dots: Fabricating Quantum Nanostructures: Solution fabrication, Lithography; Size and dimensionality effects: Size effects, Size effects on conduction electrons, Conduction electrons and dimensionality, Fermi gas and density of states, Potential wells, Partial confinement, Properties dependent on density of states; Excitons, Single electron tunneling; Applications: Infrared detectors, Quantum dot lasers.

Main References:

1. Aldert van der Ziel, Solid State Physical Electronics, 2nd edition, Prentice-Hall, New Delhi, 1971.
2. S.Y. Wang, Introduction to Solid State Electronics, North Holland, 1980,
3. R.A. Smith, Semiconductors, 2nd edition; Cambridge University Press, London, 1978.
4. Jasprit Singh, Physics of Semiconductors and their Heterostructures, McGraw-Hill, New York, 1993.
5. M.H. Brodsky (ed), Topics in Applied Physics Vol.36, Amorphous Semiconductors,
6. S.R. Elliott, Physics of Amorphous Materials, Longman, London, 1983.
7. C.S. Solanki, Solar Photovoltaics-Fundamentals, Technologies and Applications, PHI LPL, New Delhi, 2009.

8. The Physics and Chemistry of Nanosolids, *Frank J. Owens and Charles P. Poole*, Wiley-Interscience, 2008.
9. Concepts of Nanochemistry, *Ludovico Cademartiri and Geoffrey A. Ozin,* Wiley-VCH, 2009.

Additional References:

1. J.I. Pankove, Optical processes in semiconductors,
2. J. Singh, Semiconductors, Optoelectronics, Mc-Graw Hill,

Letter Grades and Grade Points

Semester GPA/Program CGPA	**% Marks**	**Letter Grade Results**
9.00-10.00	90-100	O(Outstanding)
8.00≤ 9.00	80.0≤ 90.0	A+(Excellent)
7.00≤ 8.00	70.0≤ 80.0	A(Very Good)
6.00≤ 7.00	60.0≤ 70.0	B+(Good)
5.50≤ 6.00	55.0≤ 60.0	B(Above Average)
5.00≤ 5.50	50.0≤ 55.0	C (Average)
4.00 ≤ 5.00	40.0 ≤ 50.0	P (pass)
Below 4.00		F (Fail)
Ab(Absent		Ab(Absent)

Syllabus

M.Sc.(Materials Science)

(Sem. I & II)

Team for Creation of Syllabus

Name	College Name	Sign
Prof Vaishali Bambole	University Department of Physics	
Prof Balasaheb J. Nagare	University Department of Physics	
Mr. Nitin Bijewar	University Department of Physics	

Sign of HOD

Prof. Vaishali A. Bambole

Department of Physics

Professor & Head
Department of Physics
University of Mumbai

Sign of Dean

Prof Shivram Garje

Science and Technology

Appendix B

Justification for M.Sc.(Materials Science)

1.	Necessity for starting the course:	It is basic science program to understand the physical nature
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	No. From Next Academic year 2024-25
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	self-financed At present, There is no infrastructure facility.
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	PG Diploma in Materials Science:1 year M.Sc. (Materials Science): 2 Year
6.	The intake capacity of each course and no. of admissions given in the current academic year:	Intake-30
7.	Opportunities of Employability / Employment available after undertaking these courses:	Goveronment sector, Industryandself employments

VABambole

Sign of HOD

Prof. Vaishali A. Bambole
Department of Physics

Professor & Head
Department of Physics
University of Mumbai

Garje

Sign of Dean

Prof Shivram Garje
Science and Technology