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जम्मू केंद्रीय विश्वविद्यालय
Central University of Jammu

राया–सूचानी, बागला, जिला सांबा – 181143 जम्मू, जम्मू एवं कश्मीर
Rahya- Suchani (Bagla), District Samba-181143, Jammu (J&K)

No. CUJ/11-2/CUJ/Reg/MST/2016/494

26th November, 2018

NOTIFICATION No. 74/2018

Sub: Course Scheme and Syllabus Notification of 1st to 4th Semesters of **Material Science and Technology** w.e.f. Academic Session 2018-19 – Reg.

Ref: i) Notification No. 11-2/CUJ/Reg/MST/2016/440 dated 22.08.2017
ii) Notification No. 11-2/CUJ/Reg/MST/2016/1743 dated 18.10.2017

*****

It is hereby notified for the information of all concerned that on the recommendations of the Board of Studies, Department of Nano Science and Materials and School Board, School of Basic and Applied Sciences, the Academic Council has approved the Course Scheme and Syllabus of **1st to 4th semesters of Material Science and Technology** w.e.f. Academic Session 2018-19. The approved Course Scheme and Syllabus are as follows:

*****

Semester – I

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMST1C001T	Crystal Structures and Properties of Materials	4	25	25	50	100
PGMST1C002T	Quantum Mechanics	4	25	25	50	100
PGMST1C003T	Computer Programming & Numerical Analysis	4	25	25	50	100
PGMST1C004L	Laboratory – I	4	25	25	50	100
	Elective Course (Any one)					
PGMST1E001T	Polymer Science	4	25	25	50	100
PGMST1E002T	Semiconductor Devices					
	Foundation Course (Any one)					
PGMGL0F001T	Biomolecules and Nanobiotechnology MOOC available on SWAYAM	2	12.5	12.5	25	50
	Total	22	-	-	-	550

Semester – II

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMST2C001T	Thermal Behaviour of Materials	4	25	25	50	100
PGMST2C002T	Nanomaterials	4	25	25	50	100
PGMST2C003T	Experimental Techniques in Material Science - I	4	25	25	50	100
PGMST2C004L	Laboratory - II	4	25	25	50	100
	Elective Course (Any one)					
PGMST2E002T	Thin Film Deposition and Technology	4	25	25	50	100
PGMST2E003T	Defects and Transport Phenomenon in Solids					
	Interdisciplinary Elective (Any one)					
PGEVS2I001T	Environmental Science	4	25	25	50	100

PGEVS2I001T Corrigendum under letter No.

P.T.O

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जम्मू केंद्रीय विश्वविद्यालय
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राया–सूचानी; बागला, जिला सांबा – 181143 जम्मू; जम्मू एवं कश्मीर
Rahya- Suchani (Bagla), District Samba-181143, Jammu (J&K)

No. CUJ/11-2/Reg/MST/2016/494

20th November, 2018

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Semester – I

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMST1C001T	Crystal Structures and Properties of Materials	4	25	25	50	100
PGMST1C002T	Quantum Mechanics	4	25	25	50	100
PGMST1C003T	Computer Programming & Numerical Analysis	4	25	25	50	100
PGMST1C004L	Laboratory – I	4	25	25	50	100
	Elective Course (Any one)					
PGMST1E001T	Polymer Science	4	25	25	50	100
PGMST1E002T	Semiconductor Devices					
	Foundation Course (Any one)					
PGMOL0F001T	Biomolecules and Nanobiotechnology	2	12.5	12.5	25	50
	MOOC available on SWAYAM					
	Total	**22**	-	-	-	**550**

Semester – II

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMST2C001T	Thermal Behaviour of Materials	4	25	25	50	100
PGMST2C002T	Nanomaterials	4	25	25	50	100
PGMST2C003T	Experimental Techniques in Material Science - I	4	25	25	50	100
PGMST2C004L	Laboratory - II	4	25	25	50	100
	Elective Course (Any one)					
PGMST2E002T	Thin Film Deposition and Technology	4	25	25	50	100
PGMST2E003T	Defects and Transport Phenomenon in Solids					
	Interdisciplinary Elective (Any one)					
PGEVS2I001T	Environmental Science	4	25	25	50	100

Corrigendum
Under No:- CUJ/11-2/Reg/MST/2016/111 dated 8 April 2019.
[Copy from Deputy Register Admn-HR Attached in file]

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	MOOC available on SWAYAM					
	Foundation Course (Any one)					
PGMTH2I001T	Fundamentals of Computers	2	12.5	12.5	25	50
	MOOC available on SWAYAM					
	Total	**26**	-	-	-	**650**

Semester – III

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMST3C001T	Fundamentals of Spectroscopy in Material Science	4	25	25	50	100
PGMST3C002T	Advanced Materials	4	25	25	50	100
PGMST3C003T	Advances in Crystal Growth	4	25	25	50	100
PGMST3C004L	Laboratory – III	4	25	25	50	100
	Elective Courses (Any one)					
PGMST3E002T	Smart and Responsive Materials	4	25	25	50	100
PGMST3E003T	Advanced Oxide Materials					
	Interdisciplinary Course (Any one)					
PGMST3I002T	Tools and Techniques in Molecular Biology	4	25	25	50	100
	MOOC available on SWAYAM					
	Foundation Course (Any one)					
PGMST3F001T	English Foundation	2	12.5	12.5	25	50
	MOOC available on SWAYAM					
	Total	**26**	-	-	-	**650**

Semester – IV

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMST4C001T	Experimental Techniques in Material Science - II	4	25	25	50	100
PGMST4C002T	Principal Properties of Materials	4	25	25	50	100
PGMST4C003T	Biomaterials	4	25	25	50	100
PGMST4C004D	Dissertation	8	-	-	-	200
	Elective Courses					
PGMST4E001T	Composite Materials	4	25	25	50	100
	Foundation Course					
	MOOC available on SWAYAM	2	12.5	12.5	25	50
	Total	**26**				**650**

20/11/18

Deputy Registrar
(Admin – HR)

Encl: Syllabus of 1st to 4th Semesters of Material Science and Technology

To:

Head, Department of NanoSciences and Materials

Copy to:

OSD (Exam)

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केंद्रीय विश्वविद्यालय जम्मू

Central University of Jammu

Department of Nano Sciences and Materials

4th Board of Studies

2nd June, 2018

अस्थाई अकादमिक ब्लॉक, सैनिक कालोनी, जम्मू -180011 भारत

Temporary Academic Block, Sainik Colony
Jammu-180011 - India

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Agenda of Meeting

Item No.1:	To approve syllabus for Elective and ID courses in M. Sc Material Science and Technology.
Item No.2:	To adopt MOOCs syllabus in M. Sc Material Science and Technology.
Item No.3:	To review the syllabus of M. Sc Material Science and Technology.
Item No.4:	To approve the faculty members for PhD supervision.
Item No.5:	Credit transfer with Indian/ Foreign Universities.
Item No.6:	Renaming of department as "**Department of Material Science and Technology**" instead of Department of Nano Sciences and Materials.

➢ Semester wise List of Elective Courses

I[st] Semester

Course title	course code
i. Polymer science	PGMST1E001T
ii. Semiconductor devices	PGMST1E002T

II[nd] Semester

Course title	course code
i. Thin film deposition and technology	PGMST2E001T
ii. Defect and transport in phenomena	PGMST2E002T

III[rd] Semester

Course title	course code
i. Smart and responsive materials	PGMST3E001T
ii. Advanced Oxide Materials	PGMST3E002T

IV[th] Semester

Course title	course code
i. Composite materials	PGMST4E001T

➢ Interdisciplinary courses offered by department of NanoSciences and Materials

Course title	course code
i. Nanobiotechnology	PGMST2E001T

Item No.3: To review the detailed syllabi for all semesters of M. Sc. (Material Science and Technology)

Central University of Jammu

Department of Nanoscience and Materials

Syllabus for M.Sc. Material Science& Technology

Departmental Core Course	(DCC)
Discipline Specific Elective	(DSE)
Departmental Core Practical	(DCP)
Interdisciplinary Elective	(IE)
Foundation Compulsory/Ability Enrichment	FC/ (AE) (Group-I)
Foundation Elective/Skill Based	FE/ (SB) (Group-II)

Semester I

Sr. No.	Course Code	Course Name	Course type	Credits	Contact hours per week (L-T-P)
1.	PGMST1C-001T	Crystal Structures and Properties of Materials	DCC	4	3-1-0
2.	PGMST1C-002T	Quantum Mechanics	DCC	4	3-1-0
3	PGMST1C-003T	Computer Programming & Numerical Analysis	DCC	4	2-0-4
4.	PGMST1E-001T/ PGMST1E-002T	Polymer Science / Semiconductor Devices	DSE	4	3-1-0
5.	PGMST1C-001L	Laboratory-I	DCP	4	0-0-8
6.	PGMST1FC-001T	Numerical Methods (MOOC course)/ Bio-Molecules	FC/(AE)	2	2-0-0
Total				22	13-3-12

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Semester II

Sr. No.	Course Code	Course Name	Course type	Credits	Contact hours per week L-T-P
1.	PGMST-2C 001T	Thermal Behavior of Materials	DCC	4	3-1-0
2.	PGMST-2C 002T	Nanomaterials	DCC	4	3-1-0
3	PGMST-2C 003T	Experimental Techniques in Material Science-I	DCC	4	3-1-0
4.	PGMST-2E 001T/ PGMST-2E 002T	Thin Film Deposition and Technology / Defects and transport phenomenon in Solids	DSE	4	3-1-0
5.	PGMST-2C 001L	Laboratory-II	DCP	4	0-0-8
6.	PGMST-2IE 001T	MOOC/Environmental Science	IE	4	3-1-0
7.	PGMST-2FC 001T	Computer Architecture (MOOC course) /Fundamentals of Computer	FE/(SB)	2	2-0-0
Total				26	17-5-8

MOOC course for IE

1. Basic Electrical Circuits
2. Design of Photovoltaic Systems
3. Semiconductor Devices and Circuits

Semester III

Sr. No.	Course Code	Course Name	Course type	Credits	Contact hours per week L-T-P
1.	PGMST-3C 001T	Fundamentals of Spectroscopy in Material Science	DCC	4	3-1-0
2.	PGMST-3C 002T	Advance Materials	DCC	4	3-1-0
3	PGMST-3C 003T	Advances in Crystal Growths	DCC	4	3-1-0
4.	PGMST-3E 001T/ PGMST-3E002T	Smart and responsive materials / Advanced Oxide Materials	DSE	4	3-1-0
5.	PGMST-3C 001L	Laboratory-III	DCP	4	0-0-8
6.	PGMST-3IE 002T	MOOC /Tools and Techniques in Molecular Biology	IE	4	3-1-0
7.	PGMST-3FC 002T	English Language for competitive Exams (MOOC course)	FC/(AE)	2	2-0-0
Total				26	17-5-8

MOOC course for IE

1. Solid State Physics
2. Introduction to non-linear optics and its applications
3. Manufacturing of composite Materials

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Semester IV

Sr. No.	Course Code	Course Name	Course type	Credits	Contact hours per week L-T-P
1.	PGMST4C-001T	Experimental Techniques in Material Science-II	DCC	4	3-1-0
2.	PGMST4C-002T	Principal Properties of Materials	DCC	4	3-1-0
3	PGMST4C-003T	Bio-Materials	DCC	4	3-1-0
4.	PGMST4E-001T	Composite Materials	DSE	4	3-1-0
5.	PGMST4C-001L	Dissertation	DCP	8	0-0-16
6.	PGMST4FC-002T	Soft Skills (MOOC course)	FE/(AE)	2	2-0-0
Total				26	14-4-16

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Crystal Structures and Properties of Materials

Course Code: PGMST1C001T **4 credit LTP: 3-1-0**

Unit I Crystal structure

Crystal structures and lattices with basis, Symmetry properties, Packing fractions, Miller indices, Common crystal structures, Reciprocal lattice, Brillouin zones, X-ray diffraction by a crystal and their equivalence, Laue equations, Ewald construction, Brillouin interpretation, Crystal and atomic structure factors, Structure analysis: Types of probe beam, X-ray scattering from solid including Laue conditions and line intensities, Rotating crystal and powder methods.

Unit II Lattice dynamics and thermal properties

Classical theory of lattice dynamics: Vibrations of crystals with mono-atomic and di-atomic basis's, Dispersion relations, Group velocity, Acoustical and optical modes; Phonons: Quantization of lattice vibrations, Phonon momentum, Inelastic scattering of neutrons by phonons; Thermal properties: heat capacity, Density of states, Normal modes, Debye and Einstein models for specific heat.

Unit III Electronic properties of solids-I

Free electron gas model: Electrical conductivity and Ohm's law, Density of states, Heat capacity, Fermi energy, Effect of temperature, Effective mass, Band theory of solids: Periodic potential, Bloch's theorem, Kronig-Penney model, approximate solution near a zone boundary.

Unit IV Electronic properties of solids-II

Periodic, Extended and reduced zone schemes of energy band representation. Construction of Fermi surfaces in Brillouin zones, Methods for calculations of energy bands and their features, Tight binding method and its application to simple cubic (SC) and body centred cubic (BCC) structures.

Unit V Superconductivity

Introduction to Superconductivity, Effect of magnetic field, Meissner effect, Type I and type II superconductors, Review of thermodynamic properties of superconducting materials, Isotope effect; London equation, Coherence length, BCS theory of superconductivity, Flux quantization in a superconducting ring; DC and AC Josephson effects; Macroscopic long-range quantum interference; High T_C superconductors.

Text Books:

1. Kittel, C., Introduction to Solid State Physics, Wiley.
2. Callister, W.D., Materials Science & Engineering: An Introduction, Wiley & Sons (2001).

References Books:

1. Raghvan, V., Materials Science & Engineering, PHI (1998).

2. Smith, W., Principles of Materials Science and Engineering, McGraw Hill (1990).

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Quantum Mechanics

Course Code: PGMST1C002T **4 credit LTP: 3-1-0**

Unit-I

Wave function, Properties of Wave Function, Probability Density and Probability, Conditions for Physical Acceptability of wave Functions, Normalization, Linearity and Superposition Principles, Eigen values and Eigen functions, Expectation Values, Wave Function of a Free Particle, Basic Postulates and Formalism: Energy, Momentum and Hamiltonian Operators, Time- Independent Schrodinger Wave Equation for Stationary States.

Unit-II

Normalized one and three dimension wave packets, Wave description of Particles by Wave Packets, Group and Phase Velocities and Relation between them, Schrwartz's inequality uncertainty principle, application of uncertainty principle, Expectation values of physical observables and dynamical quantities, Ehrenfest theorem, Bohr's correspondence principle, Principle of complementarities, coordinate and momentum representations, significance of momentum wave function.

Unit-III

Eigen Functions and Eigen values for a Particle in a One Dimensional Box, Bound State Problems: General Features of a Bound Particle System, (1) One Dimensional Simple Harmonic oscillator: Energy Levels and Wave Functions, Zero Point Energy; (2) Quantum Theory of Hydrogen Atom: Particle in a Spherically Symmetric Potential, Schrodinger Equation, Separation of Variables, Radial Solutions and Principal Quantum Number, Orbital and Magnetic Quantum Numbers, Quantization of Energy and Angular Momentum, Space Quantization; Electron Probability Density, Radiative Transitions, Selection Rules.

Unit-IV

Scattering Problems in One Dimension:Finite Potential Step: Reflection and Transmission, Stationary Solutions, Probability Current, Attractive and Repulsive Potential Barriers; Quantum Phenomenon of Tunneling: Tunnel Effect, Tunnel Diode (Qualitative Description); Finite Potential Well (Square Well).

Unit-V

Orbital angular moment, General formulism, Matrix representation, Geometrical representation for angular momentum, Spin angular momentum, experimental evidence of spin, General theory of spin, spin ½ and pauli matrix, Commutator algebra .

Text Books:

1. Zettili,N., Quantum Mechanics;Concept and Applications, John Wiley & Sons,LTD
2. Eisberg, R., and Resnick, R.,Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, Second Edition, John Wiley & Sons, LTD.

References Books:

3. Schiff,L.I., Quantum Mechanics, 3rd Edition, (McGraw Hill Bool Co. New York 1968).Smith, W., Principles of Materials Science and Engineering, McGraw Hill (1990).
4. Merzbacher,E.,Quantum Mechanics, 3rd Edition, (John Wiley & Sons, Inc 1997)

Computer Programming & Numerical Analysis

Course Code: PGMST1C003T **4 credit LTP: 2-0-2**

Unit I Computer Fundamentals and Programming in C

Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Unit II Numerical Methods of Analysis-I

Solution of algebraic and transcendental equations: Iterative, Bisection and Newton-Raphson methods; Solution of simultaneous linear equations: Matrix inversion method; Interpolation: Newton and Lagrange formulas

Unit III Numerical Methods of Analysis-II

Numerical differentiation, Numerical Integration: Trapezoidal, Simpson and Gaussian quadrature methods; Least-square curve fitting: Straight line and polynomial fits; Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods

Laboratory: Programming in C

1. Finding the roots of a Quadratic equation
2. Fitting a Straight line and Exponential curve
3. Fitting a Polynomial
4. Newton's Forward Difference Interpolation
5. Programming for Numerical integration: Trapezoidal and Simpson methods
6. Programming for Root finding: Bisection, Secant and Newton-Raphson methods
7. Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods

Text Books:

1. Balagurusamy, E.,Programming in ANSI C, 5th edition, McGraw Hill, New Delhi, 2011
2. Rajaraman,V., Computer Oriented Numerical Methods, 3rd edition, Prentice Hall of India, 2006

Reference Books:

1. Wong,S. S. M.,Computational Methods in Physics and Engineering, 2nd edition, World Scientific.
2. Gerald,C. F., Applied Numerical Analysis, 7th edition, Pearson/Addison Wesley, 2004
3. Teukolsky, Vetterling and Flannery,Numerical Recipes 3rd Edition: The Art of Scientific Computing, Cambridge University Press, 2007
4. Balagurusamy,E.,Object Oriented Programming With C++, 6th edition, McGraw Hill, New Delhi, 2001

Polymer Science

Course Code: PGMST1E001T **4 Credit LTP: 3-1-0**

Unit-I Introduction to Polymers

Basic concepts of high polymer system, macromolecular concept, structural feature of polymer, length to diameter ratio, classification, structure property relationship. Step reaction polymerization, radical chain polymerization, ionic and co-ordination polymerization, copolymerization.

Unit-II Polymer Chemistry

Polymerization techniques like as bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, melt polycondensation, solution poly condensation. Chemical bonds, polymer solubility, chemical reactivity, effect of thermal, photochemical and high energy radiation, aging and weathering, diffusion and permeability, toxicity, configuration of polymer chains.

Unit-III Structure and Morphology

Crystal structure of polymer, morphology of crystalline polymer, crystallization and melting, polymer single crystals, lamellae, disorder & nature of the fold surface, crystallization from melt, degree of crystallization, crystallites, structural regularity and crystallizability, factors affecting crystallisabillity, helix structure, spherulites.

Unit-IV Properties of Polymers

Glass transition temperature, melting temperature, measurement methods, factors affecting glass transition temperature and properties, Heat distortion temperature, Rheoproperties such as stress and strain, ideal elastic solid, Newtonian and non-Newtonian fluid, apparent viscosity, the power law, molecular hole concept, waissenberg effect, measurement of flow, melt fracture, time dependent flow, viscoelastic material and its mechanical model, relaxation, hysteresis and creep.

Unit-V Industrial Applications

Introduction to polymer industry, Classification of industrial polymers, Conventional to modern industrial outlook of polymers, environmental, energy and biological Industrial applications of polymers, Industrial polymer management; ethical, safety, health and environmental issues.

Text Books

1. Gowarikar,V. R. Polymer Science, 2016
2. Billmeyer, Text book of Polymer Science, John Wiley & Sons, 2007

Reference Books

3. Ghosh, P.,Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Third Edition, McGraw Hill Education 2011
4. Young, R. J.,and Lovell,P. A ,Introduction to polymers, *Polymer International*, Chapman and Hall, 1991

Semiconductor Devices

Course Code: PGMST1E002T **4 credit LTP: 3-1-0**

Unit I Microscopic Study of Solid State Devices

Allowed and forbidden energy forbidden energy bands, Direct and indirect band gap semiconductor, intrinsic carrier concentration, impurity conductivity,Density of States Function, Charge Carriers in Semiconductors, Dopant Atoms and energy Levels, Position of Fermi Level, Excess Carrier Lifetime, Surface effects.

Unit II Bipolar Devices I

PN- Junction, Zero Applied Bias, Reverse Applied Bias, Non-uniformly Doped Junctions, PN-Junction Diode, Generation- Recombination Currents, Junction Breakdown, Tunnel Diode, Schoktty Diode Metal Semiconductor Ohmic Contacts.

Unit III Bipolar Devices II

Bipolar Junction transistor (BJT) action, Minority Carrier Distribution, Low frequency common base current gain, Frequency limitation.

Unit IV Unipolar Devices

JFET, Knee Voltage, Two terminal MOS structure, Capacitance-Voltage characteristics, Basic MOSFET operation, Frequency limitations.

Unit V Optoelectronic Devices

Solar cells (Solar radiation and ideal conversion efficiency p-n junction solar cell, heterojunction and thin film solar cell), Light Emitting Diode, Photo detector (photoconductor, photodiode, photo transistor).

Text Books:

1. Neamen,D. A. Semiconductor Physics and Devices: Basic Principles, 4th edition, McGraw Hill, 2012

Text Books

1. Sze,S. M.,Physics of Semiconductor Devices, 3rd edition, Wiley, 2008
2. Streetman, B.G.,Banerjee,S., Solid State Electronic Devices, 6th edition, Prentice Hall Series, 2006

Reference Books

3. Boylestad,R. L. Electronic Devices and Circuit Theory, 10th edition, Pearson Education India, 2009

Laboratory-I

Course Code: PGMST1C001L **4 credit LTP: 0-0-8**

1. Hall-Effect measurement
2. Band-Gap of Semiconductor diode
3. Frank-Hertz experiment
4. Regulated power supply using Zener Diode
5. Photodiode
6. Preparation of unsaturated polyester
7. Measuring physical properties of Polyester/PVC
8. Four probe method Determination of resistivity of Germanium crystal at different temperature and estimation of energy band gap.
9. To study the intensity response of semiconductor materials
10. Silicon Control Rectifier (SCR) characteristics
11. Resistivity measurement of Superconducting Material
12. Study of thermoluminance property of materials

Students assigned the general laboratory work will perform at least eight (07) experiments of the above mentioned list. Experiments of equal standard may be added.

***Head of the department is authorized to add/delete/modify any other related experiments if such a need arise in future.**

References:

1. Worsnop, B.L.,and Flint, H.T.,Advanced Practical Physics for Students Methuen 1927.
2. Melissinos, A. C. and Napolitano, J., Experiments in Modern Physics, Academic Press.

Thermal Behavior of Materials

Course Code: PGMST2C001T **4 credit LTP: 3-1-0**

Unit I Classical and Quantum Statistics

Micro canonical, canonical and grand canonical ensembles, Maxwell Boltzmanns, Bose-Einstein and Fermi-Dirac statistics, Comparison of MB, BE and FD statistics.

Unit II Application of Statistics

Planck's Radiation law, Stefan-Boltzmann law, Einstein model of a solid, Bose condensation, Classical partition function and classical ideal gas, Equipartition theorem, Semiconductor statistics, Statistical equilibrium of electrons in semiconductors.

Unit III Thermodynamics-I

Laws of thermodynamics, internal energy, Enthalpy, Entropy, Helmholtz and Gibbs free energies, Thermodynamic relations, Euler equation, Maxwell's relations and applications,

Unit IV Thermodynamics-II

Chemical Potential, Gibbs phase rule, phase equilibria (single and multicomponent systems), Clausius-Clayperon equation, law of mass action, first order phase transition in single component systems, Second order phase transition

Unit V Heat and Mass Transfer

Basic concepts of conduction, convection and radiation, Hydrodynamics, Dimensionless numbers, Rayleigh's number, Reynold's number, Heat balance equation, Mass transfer convective flow, diffusion, Fick's law, diffusion coefficient-mass transfer coefficient, Application to melt growth

Text Books:

1. Lokanathan, S., and Gambhir,R. S.,Statistical and Thermal Physics:An Introduction by Prentice-Hall of India Private Limited.
2. Gupta,M. C., Statistical Thermodynamics. Wiley Eastern Ltd., New Delhi, 1993.

References:

1. Engel,T., and Reid, P., Thermodynamics, Statistical Thermodynamics & Kinetics, Pearson Education, Inc. 2006.
2. Callen, H.B., Thermodynamics and an Introduction to Thermostatistics. Wiley India Pvt Ltd.2014.
3. Holman.J.P., Heat transfer. Tata McGraw Hill, New Delhi, 2008.
4. Reif, F., Fundamentals of Statistical and Thermal Physics..McGraw Hill, 1995.

Nanomaterials

Course Code: PGMST2C002T **4 credit LTP: 3-1-0**

Unit-1: Introduction & Background

Introduction to Nanoscience and Technology, Insight and Intervention in Nanoworld, Historical Background, Recent Advances and Future Aspects, Application of Nanoscience and Technology in Different Field, Agriculture, Medical, Environmental, Defence, Food, Textiles, Consumer Etc.

Unit-2 Nanomaterials

Nanoscale materials (introduction, properties of nanomaterials, brief discussion of nanocrystals and clusters, fullerenes, carbon nanotubes, dendrimers, nano wires, nanocomposites), Quantum confinement, Band structure of solids: Free electron theory (qualitative idea) and its features, Idea of band structure, insulators, semiconductors and conductors, Energy band gaps of semiconductors, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, Variation of density of states with energy and Size of crystal.

Unit -3 Synthesis of nanomaterials

Top-down and Bottom-up approach, Synthesis methods: physical, chemical and biological methods of synthesis, Sol-Gel and Ball Milling methods, Properties of materials & nanomaterials, research and development in synthesis approach as per nonmaterial's applications, role of size in nanomaterials, Nanomaterials structures, two dimensional quantum systems, Quantum well, Quantum wire and Quantum dot, Fabrication techniques.

Unit-4 Characterizations tools and role of nanoscience in allied fields

Spectroscopic and Microscopically Techniques, Characterizations Tools for Thin film and hybrid materials, Role of nanoscience in Information Technology (Bioinformatics), Nanobiotechnology, Nano and Micro-electromechanical systems and Sensors (biosensors).

Unit-5. Ethical issues related to nanoscience and technology

Safety, Health and Environmental Issues, Societal Implications, Miscellaneous Ethical Issues related to Nanoscience and Technology:

Text Book

1. Poole, C. P., Owens,F. J.,Introduction to Nanotechnology, John Wiley & Sons, 2003
2. Kulkarni,Sulabha K.,Nanotechnology –Principle and practices, 3rd Edition, Capital Publishing Company, 2015

Reference Books

3. Nalwa,H. S., Encyclopaedia of nanoscience and technology, American Scientific Publisher, 2004
4. Folch,A., Introduction to BioMEMS, CRC Press, 2012

Experimental Techniques in Materials Science-I

Course Code: PGMST2C003T **4 credit LTP: 3-1-0**

UNIT I: X-ray Diffraction techniques

Production of x-rays, its properties and hazards, Bragg's law, Laue techniques, Debye-Scherrer techniques. Powder method for crystalline and amorphous solid, Determination of crystal structure, line broadening, particle size, residual stress measurement, Phase identification, phase quantification, Single crystal x-ray Diffraction techniques, chemical/ elemental analysis by X-ray Fluorescence.

UNIT II: Electron microscopy

Principles and operation of electron microscope, Geometry of electron microscopes, Specimen Handling and preparation, Secondary electron image, Backscattered electron image, Example of electron micro-graphs and fractography studies, Field emission –Scanning electron microscope (FESEM), Transmission Electron microscopy (TEM).

UNIT III: Scanning Probe Microscopy

Principles and operation of scanning probe microscopes: Scanning Tunnelling Microscope, Atomic Force Microscope, Magnetic and Piezo-Force microscopy, Confocal microscopy.

UNIT IV: Thermal Analysis

Thermo Gravimetric Analysis, Differential Thermal Analysis, and Differential Scanning Calorimetry: Operating principles and their applications.

UNIT V: Photometery and Spectroscopy

Basics of UV and visible Spectroscopy, Electronic transitions, Beer-Lambert Law, visible spectrum and colour; Principle and working of UV/VIS Spectrophotometer, Infrared Spectroscopy: Instrumentation and sample handling, selection rule, types of bonds, absorption of common functional group, overtones, applications of FT-IR and IR Spectroscopy.

Text Books:

1. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth-Heinemann, (1993)
2. Kauffmann, Characterization of Materials, Wiley

Reference books:

3. Cullity B. D, Elements of X-ray Diffraction., 4th Edition, Addison Wiley, 1978
4. Goodhew, P.J., and Humphreys,F.J., Electron Microscopy and Analysis, Taylor & francis, 2nd edition, 1997

Composite Materials

Course Code: PGMST4E001T **4 credit (3-1-0)**

Unit-I Introduction to Composites:

Fundamentals of composites need for composites, Enhancement of properties, Classification of composites, Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Reinforcement, Particle reinforced composites, Fibre reinforced composites. Applications of various types of composites.

Unit-II Polymer Matrix Composites:

Polymer matrix resins, Thermosetting resins, Thermoplastic resins, Reinforcement fibres, Rovings – Woven fabrics, Non woven random mats, Various types of fibres, PMC processes, Hand lay up processes, Spray up processes, Compression moulding, Reinforced reaction injection moulding, Resin transfer moulding, Pultrusion, Filament winding, Injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics.

Unit-III Metal Matrix Composites:

Characteristics of MMC, Various types of Metal matrix composites, Alloy vs. MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Reinforcements, Particles fibres, Effect of reinforcement, Volume fraction, Rule of mixtures, Processing of MMC, Powder metallurgy process, Diffusion bonding, Stir casting, Squeeze casting.

Unit-IV Ceramic Matrix Composites:

Engineering ceramic materials, Properties, Advantages, Limitations, Monolithic ceramics, Need for CMC, Ceramic matrix, Various types of ceramic matrix composites, Oxide ceramics, Non oxide ceramics, Aluminium oxide, Silicon nitride, Reinforcements, particles, Fibres- whiskers, Sintering, Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing).

Unit-V Advances in Composites:

Hybrid Composites, Carbon / carbon composites, Advantages of carbon matrix, limitations of carbon matrix Carbon fibre, Chemical vapour deposition of carbon on carbon fibre perform, Environmental effect of composites, green composites, synthesis and properties of nanocomposites, Composites for aerospace applications.

Text Books:

1. Mathews, F.L., and Rawlings, R.D., Composite materials: Engineering and Science, Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla, K.K., Composite materials, Springer – Verlag, 1987

Reference Books:

1. Clyne, T.W., and Withers, P.J., Introduction to Metal Matrix Composites, Cambridge University Press, 1993
2. Strong A.B., Fundamentals of Composite Manufacturing, SME, 1989.
3. Sharma S.C., Composite materials, Narosa Publications, 2000.

Thin Film Deposition and Technology

Course Code: PGMST2E001T **4 credit LTP: 3-1-0**

Unit-I Vacuum Science and Technology:

Kinetic Theory of Gases: Molecular Velocities, Pressure, Gas Impingement on Surfaces; Gas Transport and Pumping: Gas Flow Regimes, Conductance, Pumping Speed; Vacuum Pumps and Systems: Rotary Mechanical Pump, Roots Pump, Diffusion Pump, Turbo molecular Pump, Cryo pumps, Sputter-ion Pumps, Pressure Gauge: Pirani and Penning.

Unit-II Physics of Thin Films:

Introduction and overview, Thermodynamics and phase diagrams, Kinetics and diffusion, Nucleation and growth, Thin films growth process: Capillarity Theory, Atomistic Nucleation Processes, Cluster Coalescence and Depletion, Experimental Studies of Nucleation and Growth, Grain Structure of Films and Coatings, Amorphous Thin Films; Factors affecting film growth: Substrate, Contamination, Impinging particle energy.

Unit-III Methods of Thin Films Deposition: Chemical

Chemical Vapor Deposition: Introduction and types of reactions; Growth kinetics: Growth Rate Uniformity, Temperature Dependence, Thermodynamic Considerations, Structure; CVD Processes and Systems, Other commonly used techniques: Chemical bath deposition, Langmuir Blodgett, Spin casting.

Unit-IV Methods of Thin Films Deposition: Physical

Thermal evaporation, e-beam deposition, Sputtering techniques: Process, Merits of sputtering, Applications of sputtering, DC sputtering, Principle of rf-sputering, Description of the sputtering unit, Pulsed laser deposition: Laser, Optics, Laser-target interaction, Plume dynamics, and experimental setup.

Unit-V Methods of Thin Films Deposition: Advance Techniques

Surface processes in epitaxial growth: Growth modes and surface energies, Surface processes in crystal growth, Thermodynamics and kinetic arguments; Molecular beam epitaxy, Laser molecular beam epitaxy, Atomic layer deposition: Physisorption, Chemisorption, Thermal ALD Processes.

Text Books:

1. Ohring, M.,The Materials Science of Thin Films, Academic Press

2. Seshan, K.,Hand Book of Thin Film Deposition processes and Techniques:Principles, Methods, Equipment and Applications, Second Edition, Noyes Publications &Willam Andrew Publishing Norwich, New York, U.S.A.

Reference books:

1. Eason, R., Pulsed Laser Deposition of Thin Films, Application-LED Growth of Functional Materials,Wiley, 2007
2. Smallman, R.R., Ngan, A. H. W., Physical Metallurgy and Advanced Materials, Elsevier, 2007
3. Hwang, C. S., Yoo, C. Y., Atomic Layer Deposition for Semiconductors, Springer
4. King, D.A., Woodruff, D. P., The Chemical Physics of Solid Surfaces:Growth and Properties of Ultrathin Epitaxial Layers, Volume 8, John Wiley & Sons (1986)
5. Wasa, K., Kitabatake, M., Adachi, H.,Thin Films Materials Technology: Sputtering of Compound Materials, Springer

Defects and Transport in Solids

Course Code: PGMST2E002T **4 credit (3-1-0)**

Unit-I Point Defects

Point and Electronic Defects in Crystalline Solids, Electronic Properties, Optical Properties: F Centers, Bulk Properties: Unit Cell Dimensions, Density, Volume etc.; Thermoelectric Properties: The Seebeck Coefficient as an Example, Charges on Defects: Electrons and Electron Holes, Atomic and Ionic Defects; Balanced Populations of Point Defects: Schottky and Frenkel Defects; Antisite Defects, Combinations of Point Defects in Pure Materials, Structural Consequences of Point Defect Populations

Unit-II Intrinsic Point Defects in Stoichiometric Compounds

Equilibrium Population of Vacancies in a Monatomic Crystal, Equilibrium Population of Self-Interstitials in a Monatomic Crystal, Equilibrium Population of Schottky Defects in a Crystal, Equilibrium Population of Frenkel Defects in a Crystal, Equilibrium Population of Antisite Defects in a Crystal

Unit-III Extended Defects

Dislocations, Edge Dislocations, Screw Dislocations, Mixed Dislocations, Unit and Partial Dislocations, Multiplication of Dislocations, Dislocations in Nonmetallic Crystals, Internal Boundaries, Low-Angle Grain Boundaries, Twin Boundaries, Antiphase Boundaries, Volume Defects and Precipitates

Unit-IV Defects and Diffusion

Diffusion in Solids, Random-Walk Diffusion in Crystals, Diffusion Mechanisms: Vacancy Diffusion, Interstitial Diffusion, Impurity and Cluster Diffusion Mechanisms; Point Defect Concentration and Diffusion, Dislocation and Grain Boundary Diffusion

Unit-V Intrinsic and Extrinsic Defects in Insulators

Ionic Conductivity in Solids: Fundamental Concepts, Mechanisms of Ionic Conductivity: Random-Walk Model, Relationship between Ionic Conductivity and Diffusion Coefficient, Ionic Conductivity and Defects; Disordered Cation Compounds

Text Books

1. R. J. D. Tilley, Defects in solid, John Wiley & Sons, 2008
2. P. Kofstad and T. Norby, Defects and Transport in crystalline solids,

Laboratory-II

Course Code: PGMST2C001L **4 credit (0-0-8)**

1. PCM/delta modulation and demodulation
2. Fiber optic communication
3. Determination of the specific heat
4. Measurement of Dielectric constant
5. BH Curve
6. Electrochemical work station (portable)
7. Interferometric method for thin film thickness and strain measurement
8. Metallographic microscope to see grain boundaries.
9. Effect of Temperature on grain boundaries of metallic samples.
10. Study of temperature vsemf characteristics
11. Synthesis of nanomaterials and its characteristics
12. To study the fiber and wide fraction of composite material
13. Study of crystal structure using XRD

Students assigned the general laboratory work will perform at least eight (07) experiments of the above mentioned list. Experiments of equal standard may be added.

***Head of the department is authorized to add/delete/modify any other related experiments if such a need arise in future.**

References:

1. Worsnop,B.L.,and Flint,H.T.,Advanced Practical Physics for Students Methuen 1927.
2. Melissinos, A. C., andNapolitano,J., Experiments in Modern Physics, Academic Press

Fundamentals of Spectroscopy in Material Science

Course Code: PGMST-3C 001T **4 credit LTP: 3-1-0**

Unit–IAtomic Spectroscopy:

Quantum states of hydrogen like atomic systems, Fine structure, Relativistic correction, spin-orbit coupling, Spectroscopic terms and selection rules, Zeeman and Paschen-Back effect, Hyperfine structure, Lamb shift

Unit–II Identical Particles:

Identical particles, spectra of two-electron atomic systems, Independent particle model, exchange effects

Unit–III Multi electron spectroscopy:

Multi electron atoms, Pauli principle and periodic table, Central field approximation, Hartreeself-consistent field method, coupling schemes for many electron atoms, L-S and j-j coupling schemes, equivalent electrons

Unit-IV Molecular spectroscopy:

Rotation, Rotation-Vibration spectra, Raman spectra, Selection rules,nuclear spin and intensity alteration, Isotope effect, Frank-Condon principle

Unit-V Laser:

Lasers, Spontaneous and stimulated emission, Optical pumping, Population inversion. Coherence, Simple description of ammonia and He-Ne Laser

Text Books:

1. Bransden, B. H. & Joachin, C. H., Physics of Atoms and Molecules, Prentice Hall; 2nd edition, 2003
2. Kumar,R., Atomic & Molecular Spectra: Laser, Publisher: Knrn (2012)

Reference books:

i. Ghoshal, S.N, Atomic Physics (Modern Physics), Publisher: S. Chand, 2010 Physics of Atoms and Molecules, Prentice Hall; 2 edition, 2003
ii. Banwell, C. and Mccash, E. Fundamentals for Molecular Spectroscopy, McGraw Hill Education; 4 edition

Advanced Materials

Course Code: PGMST3C002T **4 credit LTP: 3-1-0**

Unit -I Introduction :

Introduction and structure of materials, why study properties of materials? Structure of atoms - Quantum states-Atomic bonding in solids-binding energy-interatomic spacing - variation in bonding characteristics - Single crystals – polycrystalline - Non crystalline solids - Imperfection in solids – Vacancies – Interstitials - Geometry of dislocation - Schmid's law - Surface imperfection - Importance of defects - Microscopic techniques - grain size distribution

Unit – II Structural materials:

Structural Materials: Porous matrix ceramics- composites, Metallic foam, Solid solutions and alloys - Phase diagrams - Gibbs phase rule - Single component systems – Eutectic phase diagram – lever rule - Study of properties of phase diagrams - Phase transformation - Nucleation kinetics and growth

Unit – III Features of advanced materials:

Electronic, optical and magnetic properties of advanced materials, Optical properties - Light interaction with solids - Atomic, electronic interaction, non – radiative transition - refraction, reflection, Absorption, Transmission, Insulators, luminescence, Mechanical properties - Stress, Strain, Elastic properties – Deformation – elasticity – hardness, mechanically alloyed oxide dispersion strengthened superalloys, High strength and ductile bulk quasi crystalline alloys and their composites, Thermal barrier coating for aero engines and gas turbines. Processing of Ni- base superalloys for turbine engine discs, Gamma- Titanium aluminades.

Unit -IV Crystalline materials:

Glassy and Nano crystalline materials, different magnetic properties and energy, environmental and biological applications, paramagnetism - ferromagnetism - domain theory - magnetic hysteresis, Weiss molecular field theory, Heisenberg's theory - magnetic anisotropy - domain walls - Exchange energy –antiferromagnetism, piezoelectric, optoelectric, semiconducting behavior

Unit V – Functional and Smart Materials:

Functional Materials: Low and high dielectric constant materials, optoelectronic materials. Smart Materials: Shape memory alloys, hydrogen storage alloys, Functionally gradient material (FGM), Bulb memory.

Text Books

1. Gandhi, M.V., Thompson, B.S., Smart Materials and Structures, Chapman and Hall
2. Ray, A.K. (ed), Advanced Materials, Allied publishers
3. Rama Rao, P. (ed), Advances in Materials and their applications, Wiley Eastern Ltd.
4. Bhushan, B., Nano Technology (ed), Springer
5. V. Raghavan, "Materials Science and Engineering: A First Course", Prentice Hall, 2006
6. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.

Advances in Crystal Growth

Course Code: PGMST3C003T **4 credit LTP: 3-1-0**

Unit-I Crystal Growth Theory:

Introduction to crystal growth, nucleation, Gibbs-Thomson equation, kinetic theory of nucleation, limitations of classical nucleation theory, homogeneous and heterogeneous nucleation, different shapes of nuclei, spherical, cap, cylindrical and orthorhombic, Temkins model, physical modeling of BCF theory.

Unit-II Melt Growth:

Temperature measurement and control, Starting materials and purification, conservative and non-conservative process, Bridgman method, Czochralski method, Verneuil method, Zone melting, Fluid flow analysis in melt growth, theory and experiment.

Unit-III Solution Growth

Low temperature solution growth: Solution, Solubility and supersolubility, Expression of supersaturation, Miers T-C diagram, constant temperature bath and crystallizer, Seed preparation and mounting, Slow cooling and solvent evaporation methods, Gel growth various types, Structure of gel, Importance of gel technique, Chemical reaction method, single and double diffusion method, Chemical reduction method, Complex and decomplexion method, Solubility reduction method, Advantages of gel method, High temperature solution growth, Hydrothermal growth, Flux growth.

Unit-IV Vapor Growth:

Physical vapour transport, Chemical vapour transport, Epitaxial growth techniques, Liquid phase epitaxy, Vapour phase epitaxy, Molecular beam epitaxy, Chemical beam epitaxy, Growth for polycrystalline materials, Quality assessment by x-ray diffraction and optical techniques, Current trends in crystal growth, Quantum wells and superlattices, Heterostructures.

Unit-V Liquid Crystal and Devices:
Introduction of different types of liquid crystals; Symmetry, Textures, Microscopic and optical properties of different types of nematic, Smectic and cholesteric liquid crystal, Blue phases, Electrical and dielectric properties of liquid crystal, Electrohydrodynamics (EHD) instability of liquid crystal, Chiral liquid crystals, Ferroelectric liquid crystals, Electro-optic and magneto-optic effect of liquid crystals, display and memory devices, Applications of liquid crystals.

Text & Reference Books:

1 Bric, J.C.,Crystal growth Processes, John Wiley and sons, New York1986.
2 Pamplin, B.R.,Crystal Growth, Pergamon press, London1975.
3 Streetman, B.G., Solid State Electronic Devices, PHI, (2005)
4 Fleming, M.C., Solidification Processing, McGraw Hill (1974)

Smart and Responsive Materials

Course Code: PGMST **4 credit LTP: 3-1-0**

Unit **I**

Introduction of Liquid Crystals

Liquid crystals (LCs), Classification of LCs: Thermotropic, Lyotropic and Mettalotropic LCs, Discotic liquid crystals, Biological liquid crystals, Chiral liquid crystals, Ferroelectric liquid crystals, Anti- Ferroelectric liquid crystals, Polymer liquid crystals.

Unit **II**

Phase Transitions in Liquid Crystals

Liquid crystal phases, Nematic, chiral nematic/Cholesteric Phase, Blue Phase, Smectic Phase: SmA, SmB, SmC, I, F, G, M phases, SmA*,SmC*, SmC_A*, SmCα*, SmC_β*, SmC_γ* Phases, Phase transitions in LCs: Nematic {isotropic (N- I) phase transition, Hard rod model of N-I phase transition, Numerical methods for studying liquid crystal phase transitions.

Unit **III**

Electrical and Optical characterizations of LCs

Electrical, optical and electro-optical properties of liquid crystals, Determination of phase transition temperature, Identification of different LC phases from texture studies, Switching studies of LCs and determination of switching time, switching voltage and threshold voltage.

Unit **IV**

Electrically responsive polymers

Conjugated polymers, intrinsically conductive polymers, Polymers with piezoelectric and ferroelectric properties. Polymers used for field emission transistors (FET), organic light emitting diodes and Organic Photovoltaics.

Unit **V**

Magnetically responsive polymers

Magnetically active polymers: Origin of magnetism in polymers, Iron, nickel, cobalt, ruthenium, osmium containing magnetic polymers, magnetic polymers with conductivity.

Text and Reference Books:

1. Faiz Mohammad, Specialty Polymers: Materials and Applications, I.K. International Pvt Ltd, 2008
2. Peter J Collings, Nature's Delicate Phase of Matter, Princeton University press, 1990
3. P G de Gennes, J. prast, The Physics of Liquid Crystals, Clarendon Press, 1995

Advanced Functional Oxide Materials

Course code: PGMST-3E002T **4 Credit LTP: 3-1-0**

Unit I

High–Tc Superconductors, Cuppurate Materials, Magnetic and Electrical properties, flux pinning and flux dynamics Application in superconducting magnets, micro strip resonators and filters Colossal magnets resistance (CMR) materials: Introduction to pervoskite materials, electrical and magnetic sensors, read- write heads.

Unit II

Magnetic oxide materials, Ferromagnetic oxide materials, Ferrites materials, Applications of Ferrites Ferroelectric and Dielectric Materials, origin of dielectrics, ferroelectrics, piezoelectric, pyroelectric properties and their Application.

Unit III

Spintronics, History and overview of spin electronics, quantum mechanics of spin, spin-orbit interaction, exchange interaction, Basic mechanism of spin polarization, spin relaxation mechanisms, spin-dependent electron transport, spin injection.

Unit IV

Multiferroic Materials: Origin of magnetic ordering in the oxide materials, origin of ferroic in electric odide ordering in oxide materials. Coupling of magnetic and electric dipole ordering. Possible materials and their engineering for multiferroic properties and their future application.

Unit V

Introduction to Non Linear Optics, Non Linear Optical Materials, Second and third harmonic generation NLO materials, Z-Scan technique. Non-linear optical effect: Basic theory of NLO effect, applications of NLO materials, various NLO-parameters,

Texts and References:

1. **S. Bandyopadhyay, M. Cahay**, Introduction to spintronics, CRC Press, 2008.
2. **J.P. Jakubovics**, Magnetism and Magnetic Materials, Institute of Materials, London,1994
3. **Z.L Wang,** Characterization of nanophase materials- Wiley- VCH, 2000
4. **S. Maekawa**, Concepts in spin electronics, Oxford University Press, 2006.

Laboratory-III

Course Code: PGMST3C001L **4 credit (0-0-8)**

1. Synthesis of Semiconductor/Metal Nanoparticles
2. Synthesis of Composite Materials
3. Fabrication of Liquid Crystal
4. Thin film growth by chemical route
5. Thin film growth by physical route
6. Morphological study using AFM/SEM
7. Bandgap and particle size calculation using UV-Visible spectroscopy
8. Defect analysis using Fluorescence/ PL spectroscopy
9. Study of electrical properties using I-V/C-V/Hall effect measurement

Students assigned the general laboratory work will perform at least eight (07) experiments of the above mentioned list. Experiments of equal standard may be added.

***Head of the department is authorized to add/delete/modify any other related experiments if such a need arise in future.**

Experimental Techniques in Materials Science-II

Course Code: PGMST4C001T **4 credit (3-1-0)**

Unit-I Mechanical Characterization:

Tension Testing: Indication of the Material's Toughness, Analysis of Stress/Strain Curves, Factors Affecting the Form of the Stress/Strain Curve, Material and Microstructure, Effects of Temperature and Strain Rate, Practical Aspects of the Method; Fracture Toughness Testing Methods: Principles of Method, Load-Displacement Behaviors, Stress Intensity Factor, Practical Aspects of the Method Hardness Testing.

Unit-II Optical Characterizations:

Raman spectroscopy: Raman scattering, Experimental setup, Quantitative Analysis; Lumineasence: Radiative-nonradiative recombination, Type of luminescence, Band Edge Emission, Defect Emission, Activator emission, Luminescence decay; Photoluminescence spectroscopy: Fluorescence and Phosphorescence, experimental setup; Time resolve photoluminescence spectroscopy.

Unit-III Electrical and Electronic Characterizations:

Conductivity Measurement: Principles of the Method, Practical Aspects of the Method, Sample Preparation; Hall measurement: Principles of the Method, Practical Aspects of the Method, Sensitivity, Sample Preparation, Problem; Current-Voltage measurement: Principles of the Method, Practical Aspects of the Method; Capacitance-Voltage measurement: Principles of the Method,Practical Aspects of the Method, C-V Profiling equipment.

Unit-IV Magnetic Characterizations:

Magnetometry: Principles of the Method, Practical Aspects of the Method, Flux-Integrating Magnetometer, Electron Paramagnetic Resonance Spectroscopy, Nuclear Magnetic Resonance, vibrating sample magnetometery (VSM) and superconducting quantum interference device (SQUID).

Unit-V Experimental Errors and Error Analysis:

The Purpose of Error Analysis, trail measurements and statistics, Random variation, Probability theory in statistics, Computed measurements, Types of errors: random error, systematic error, precision and accuracy, Determining the Precision, discrepancy, blunders, Rejection of Measurements; typical distributions,

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Text Books:

1. Kauffmann, Characterization of Materials, Wiley
2. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth-Heinemann, (1993)

Reference books:

1. Perry, D. L., Applications of Analytical Techniques to theCharacterization of Materials, Springer Science+Business Media, LLC
2. Vij, D. R., Handbook of Applied Solid State Spectroscopy, Springer
3. Smallman, R.R., Ngan, A. H. W.,Physical Metallurgy and AdvancedMaterials, Elsevier, 2007
4. Schoder, D. K., Semiconductor Materials and Device Characterization, John Wiley& Sons, Inc., Publication

Principal Properties of Materials

Course Code: PGMST4C-002T **4 Credit LTP: 3-1-0**

Unit –I Mechanical Properties:

Stress and strain behavior, Elastic properties of materials, Plastic deformation, tensile strength and modulus of elasticity, compressive and shear deformation, hardness, creep, fracture, fatigue.

Unit –II Transport Properties:

Introduction to transport properties, Boltzmann transport equation, Sommerfield theory of electrical conductivity, Relaxation time, mean free path, thermal conductivity, Hall effect, Hall voltage, Hall coefficient, Mobility and Hall angle, cyclotron resonance, Drift velocity, scattering by phonons, thermoelectric effect

Unit –III Dielectric properties of solids:

Polarization and susceptibility, Local field, Dielectric constant, Sources of Polarizability, Electronic, ionic and dipolar polarizability, Frequency dependence of polarizability, Ferroelectricity, Piezoelectricity

Unit – IV Magnetic Properties:

Origin of magnetism, Magnetic terminology, types of magnetism, Para-magnetism, diamagnetism, Langevin's classical theory dia- & para-magnetism, ferro and ferrimagnetism, Weiss theory of ferromagnetism, Anti-ferromagnetism

Unit -V Optical Properties:

Refractive index, absorption and transmission of electromagnetic radiation in solids, electro-optic and magneto-opticmaterials, luminescence, thermal emission, photo-conductivity

Text Books:

1. Puri, R. K., and Babbar, V.K.,Solid State Physics, S. Chand; 2nd edition, 2003
2. Pillai, S.O.,Solid State Physics, Publisher: New Age International Pvt Ltd; Seventh edition 2015
3.Sirdeshmukh, D., Sirdeshmukh, L., Subhadra, K. G., Sunandana, C. S.,Electrical, Electronic and Magnetic Properties of Solids, Springer; 2014 edition, 2014
4. Callister, W. D.,Materials Science and Engineering, Wiley Eastern Limited, 1984.

Reference books:

1. White, M. A., Physical Properties of Materials, Publisher: CRC Press; 2 edition (22 June 2011
2. Kjelle, M. M., The Properties of Solids, PowerkidsPr (31 August 2006)

Biomaterials

Course Code: PGMST4C003T **4 Credit LTP: 3-1-0**

Unit-I Introduction:

Fundamentals of biomaterials science. Synthesis of biomaterials, Concept of biocompatibility. Classes of biomaterials used in medicine, basic properties, medical requirements and clinical significance. Disinfection and sterilization of biomaterials.

Unit–II Properties:

Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, physical (electrical, optical, magnetic, thermical), chemical and biological properties.

Unit-IIIBiological composition and process:

Elements in contact with the surface of a biomaterial: blood composition, plasma proteins, cells, tissues. Phenomena at the biointerfaces. Molecular and cellular processes with living environment, blood-materials interaction, short and long term reactions to the body. Testing of biomaterials: in vitro, in vivo preclinical and in vivo clinical tests.

Unit-IV Industrial applications:

Technologies of biomaterials processing, implantation and medical devices; improvement of materials biocompatibility by plasma processing, clean energy and environmental applications

Unit-V Ethical issues related to biomaterials:

FDA requirements, standards on the biological evaluation of medical devices (ISO-10993) and implications to applications in human. Practical aspects of biomedical devices: manufacturing, storage quality, regulatory and ethical issues, price of implants and allocation of resources.

Books:

1. Boenig, H., Fundamentals of Plasma Chemistry and Tehnology, Technomic Publishing Co.Inc. Lancaster Basel, 1990.
2. Briggs, D., and Seah,M.P.,Practical Surface Analysis, 2- edition, J.Wiley& Sons Ltd, 1990.
3. Ratner, B. D. and Hoffman,A. S., Biomaterials Science, An Intoduction to Materials in medicine, Eds. Academic Press, New York, 1996.
4. Chua,P.K., Chena,J.Y., Wanga, L.P., and Huang,N.,Plasma-surface modification of biomaterials, Elsevier Science B.V, 2002.
5. Articles about Biomaterials and Biocompatibility

Composite Materials

Course Code: PGMST4E001T

4 Credit LTP: 3-1-0

Unit-I Introduction to Composites:

Fundamentals of composites need for composites, Enhancement of properties, Classification of composites, Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Reinforcement, Particle reinforced composites, Fibre reinforced composites. Applications of various types of composites.

Unit-II Polymer Matrix Composites:

Polymer matrix resins, Thermosetting resins, Thermoplastic resins, Reinforcement fibres, Rovings – Woven fabrics, Non woven random mats, Various types of fibres, PMC processes, Hand lay up processes, Spray up processes, Compression moulding, Reinforced reaction injection moulding, Resin transfer moulding, Pultrusion, Filament winding, Injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics.

Unit-III Metal Matrix Composites:

Characteristics of MMC, Various types of Metal matrix composites, Alloy vs. MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Reinforcements, Particles fibres, Effect of reinforcement, Volume fraction, Rule of mixtures, Processing of MMC, Powder metallurgy process, Diffusion bonding, Stir casting, Squeeze casting.

Unit-IV Ceramic Matrix Composites:

Engineering ceramic materials, Properties, Advantages, Limitations, Monolithic ceramics, Need for CMC, Ceramic matrix, Various types of ceramic matrix composites, Oxide ceramics, Non oxide ceramics, Aluminium oxide, Silicon nitride, Reinforcements, particles, Fibres- whiskers, Sintering, Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing).

Unit-V Advances in Composites:

Hybrid Composites, Carbon / carbon composites, Advantages of carbon matrix, limitations of carbon matrix Carbon fibre, Chemical vapour deposition of carbon on carbon fibre perform, Environmental effect of composites, green composites, synthesis and properties of nanocomposites, Composites for aerospace applications.

Text Books:

1. Mathews, F.L., and Rawlings, R.D., Composite materials: Engineering and Science, Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla, K.K., Composite materials, Springer – Verlag, 1987

Reference Books:

1. Clyne, T.W., and Withers, P.J., Introduction to Metal Matrix Composites, Cambridge University Press, 1993
2. Strong A.B., Fundamentals of Composite Manufacturing, SME, 1989.
3. Sharma S.C., Composite materials, Narosa Publications, 2000.

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