ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
MANGALORE UNIVERSITY
(Accredited by NAAC Grade)

ಕ್ರಮಾಂಕ/No. : MU/ACC/CR.4/2025-26/A2

ಕುಲಸಚಿವರಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:31.07.2025

# NOTIFICATION

Sub: Syllabus of P.G. Diploma in Materials Science Programme.

Ref: Academic Council approval vide agenda No.: ಎಸಿಸಿ:ಶೈ.ಮ.ಸಾ.ಸ.1:1 (2025-26) dtd 18.07.2025.

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The syllabus of P.G. Diploma in Materials Science programme which has been approved by the Academic Council at its meeting held on 18.07.2025 is hereby notified for implementation with effect from the academic year 2025-26 and onwards.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

REGISTRAR

To,

1. The Registrar (Evaluation), Mangalore University.
2. The Chairman, PG BOS in Materials Science, Dept. of Materials Science, Mangalore University, Mangalagangothri.
3. The Chairman, Dept. of Materials Science, Mangalore University, Mangalagangothri.
4. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
5. The Director, DUIMS, Mangalore University – with a request to publish in the website.
6. The Case workers of A4, A7, A9 of Academic Section, O/o the Registrar, Mangalore University.
7. Guard File.

MANGALORE UNIVERSITY

Accredited by NAAC

**Department of Materials Science**

Mangalagangothri– 574199

Syllabus for **Post Graduate Diploma Programme**

**in**

**Materials Science**

**May 2025**

# MANGALORE UNIVERSITY

## REGULATIONS GOVERNING "POST GRADUATE DIPLOMA PROGRAMME IN MATERIALS SCIENCE"

1. **Title:** The Programme shall be called "**Post Graduate Diploma Programme in Materials Science"**

2. **Eligibility for Admission:**

2.1 Candidates who have passed any B.Sc Programme of Mangalore University or of any other University/Recognized Bodies considered as equivalent thereto, with Physics/Chemistry as one of the optional/ major/special subject.

**OR**

Candidates who have passed any Bachelor Degree Programme of Mangalore University or any other University/Recognized Bodies considered as equivalent thereto, with Physics and Chemistry at P.U.C./Higher Secondary level

**OR**

Candidates who have passed Bachelor's degree in Engineering/ Technology from any of the recognized University in India/abroad with Physics/ Chemistry at P.U.C./Higher Secondary level

2.2 Selection on the basis of merit and according to the Government's reservation policy existing at that time.

3. **Duration:**

Post Graduate Diploma Programmes shall extend over a period of one academic year split into two semesters.

4. **Medium of Instruction:**

The medium of instruction and examination shall be in English.

5. **Hours of Instruction**: There shall be 20-22 hours of instruction per week totaling 640 hours of instruction per year.

6. **Attendance:**

Each Course shall be treated as an independent unit for the purpose of attendance. A student shall attend a minimum of 75% of the total instruction hours in a course including tutorials and seminars. There shall be no provision for condonation of shortage of attendance and a student who fails to secure 75% attendance in any course is not eligible for appearing for the examination of that course. He/she shall be required to repeat that programme for that semester.

7. **Maximum Period For Completion of the Programme**:

The candidate shall complete the programme within the period prescribed in the regulations governing maximum period for completing various degree/ diploma programmes notified by the University from time to time.

8. **INSTRUCTION HOURS & SCHEME OF EXAMINATION:**

These programmes will commence ordinarily in June/July. The end semester examinations of the P.G. Diploma will be held in October/November. The second semester examination will be conducted towards the end of academic year ordinarily during April/May Post Graduate Diploma Programmes. The scheme of examination is as below:

**P.G. DiplomaProgrammes (I and II Semesters):**

| Subjects | Cre-dits | Instruction Hours | Duration of Exams (Hrs) | Marks | | |
|---|---|---|---|---|---|---|
| | | | | I.A | Exam | Total |
| **MSPGD 401:** Classification of Materials | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 402:** Principles of Crystal Structure Analysis | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 403:** Mechanical Behaviour of Materials | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 404:** Materials for | 4 | 4 | 3 | 30 | 70 | 100 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sustainable Energy | | | | | | |
| **MSPGD 405:** Practicals 1 | 4 | 4 | | | 50 +50 | 100 |
| | **20** | | | | | **500** |
| | | | | | | |
| **MSPGD 451:** Advanced Functional Materials | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 452:** Device Fabrication Technology | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 453:** Materials Characterization-I | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 454:** Materials Characterization-II | 4 | 4 | 3 | 30 | 70 | 100 |
| **MSPGD 455:** Practicals II | 4 | 4 | 3 | 30 | 50+ 50 | 100 |
| | **20** | | | | | **500** |
| Total | **40** | | | | | **1000** |

**9. Internal assessment:**

9.1 The Internal assessment marks are based on one test and assignments.

9.2 Marks of the internal assessment must be published on the Notice Board of the concerned department for the information of the student.

9.3 Marks scored in the internal assessment shall be indicated separately in the Marks card.

9.4 Internal assessment marks of a failed candidate shall be retained and carried forward to his/her subsequent examinations.

9.5 The Internal assessment marks shall be communicated to the Registrar (Evaluation) at least 7 days before the commencement of the University Examination.The record of internal assessment shall be maintained in the department and Registrar (Evaluation) shall have access to such records.

**10. Registration for Examinations**:

A candidate shall register for all the courses in the subject when he/she appears for the examination for the first time at the stipulated date laid down by the University.

**11. Valuation of answer scripts**:

Each theory/practical course shall be evaluated by eligible examiners as decided by concerned Boards of Studies.

## 12. Provision for revaluation, retotalling and issuing photocopy of answer scripts:

Students can apply for revaluation/retotalling of marks awarded/personal seeing of answer scripts/obtaining the photocopies of the answer scripts within the specified date by paying prescribed fees.

## 13. Minimum percentage of marks for passing the Examination:

13.1 Any candidate who has obtained a minimum of 35% in each course and 40% in aggregate (including internal assessment) shall be declared to have passed the exam.

13.2 There shall be no minimum in respect of internal assessment.

13.3 A candidate who fails in any of the theory courses shall reappear in that theory course in the subsequent examination.

## 14. Classification of successful candidates:

The results of successful candidates at the end shall be classified on the basis of aggregate marks obtained.

| | |
|---|---|
| First Class with Distinction: | 70% and above |
| First Class: | 60% and above but less than 70% |
| Second Class: | 50% and above but less than 60% |
| PassClass: | 40% and above but less than 50% |

## 15. Improvement of Results

15.1 A candidate may be permitted to improve his/her results in a particular course by rejecting his/her existing results within 30 days after the declaration of the result and reappear for the examination whenever the said examination is notified. In case the candidate secures fewer marks in the reappearance examination, she/he may retain the previous results.

15.2 The rejection option shall be exercised only once and the rejection once exercised cannot be revoked.

15.3 Application for rejection and improvement shall be submitted along with the payment of the prescribed fee through the department/college, together with the original statement of marks.

15.4 The internal assessment marks secured by the candidate during the programme shall be carried forward.

15.5 A candidate who appears for improvement is not eligible for inclusion in the rank list.

16. **Penalty for False and incorrect Statement:**

Where the candidate or his/her parent or guardian furnishes false or incorrect statement in an application or where the affidavit filled by him/her or the certificates furnished by him/her contains false or incorrect statements such an application shall be rejected and his/her admission shall stand cancelled

## MANGALORE UNIVERSITY

## ONE YEAR PG DIPLOMA PROGRAMME IN MATERIALS SCIENCE

The PG Diploma programme in Materials Science syllabus is framed based on industry manpower and R&D skill requirements.

**Learning Objectives**: Materials Science is an interdisciplinary field in science and technology that integrates the physical, chemical, and engineering aspects of materials. It comprises the study of materials' structure, properties, and applications.

The objectives of this course are to (i) impart structure-property-based knowledge in the area of Materials Science. (ii) foster a conducive learning environment for students to understand and apply their knowledge in data collection and analysis related to materials characterization. (iii) produce quality human resources in Materials Science for the requirements in industries and R&D (iv) understand the principles of cutting-edge technology in semiconductors and sustainable development.

**Programme outcome:**

The following attributes summarizes the programme outcome

(i) **Interdisciplinary Approach**: Students will understand how this interdisciplinary approach can be harnessed to provide better solutions for the sustainable developments.

(ii) **Knowledge Skills**: Students are able to independently analyze concepts logically, think objectively from a reasoned perspective, and draw reasonable conclusions, a major requirement in knowledge assimilation and dissemination.

(iii) **Skills in research and industries:** The rigorous laboratory training and teaching objectives in various materials synthesis and characterization serve to instil skills for research and industry. Also, boost self-confidence and personality development, thereby enabling one to be successful in interviews and placements in research laboratories or industries.

(iv) **Entrepreneurship:** Apply knowledge to build up small-scale industry for developing indigeneous products.

(v) **Personality Development**: Students will imbibe ethical, moral, and social values in personal and social life, leading to a highly cultured and civilized society. They will also realize that the pursuit of knowledge is a lifelong activity combined with untiring efforts and a positive attitude.

**Programme specific outcome**: Research in Materials forms the foundation for any development in Science and Technology. Hence, by the end of the programme, the students will be able to (ii) find placement in industries related to Materials Research and Characterization laboratories in India and abroad. (iii) develop industrial products and excel as entrepreneurs. (iv) be able to continue as interns in industries and laboratories. (vi) design and execute an original plan of action in any scientific pursuit.

**Course Outcomes**: Each of the courses is designed in such a way that they equip the graduate with the necessary knowledge and skills for pursuing a career in industries/research laboratories. In addition,

(i) The student is able to appreciate the importance of choosing the right materials for different applications. Students also acquire knowledge of the different techniques available to characterize materials for their strength, structure, purity etc.

(ii) Students also learn the basics and applications of currently developing fields such as nanotechnology, conducting polymers, and smart materials.

(iii) The student acquires the basic skills in data analysis related to materials research. The students are thus trained for working in industries associated with materials research.

## POSTGRADUATE DIPLOMA PROGRAMME IN MATERIALS SCIENCE

## I SEMESTER

**Course I: 4 Credits**

**MSPGD 401: Classification of Materials**

**Objectives:** The objective of the present course is to provide a basic understanding of (i) the different classes of materials based on their properties, (ii) technologically important materials such as metals, semiconductors, polymers, composite materials, and ceramic materials (iii) how these properties can be harnessed for various applications

**Expected course outcomes:** The student is capable of gaining sufficient knowledge on (i) the properties required for a material for specific applications (ii) what factors determine the choice of materials for the desired application.

**Unit I**

Conductors: metals - definition, elementary ideas of electrical properties, optical properties, mechanical properties, thermal properties. Specific examples of metals- copper, aluminium, iron, gold, silver. Uses of metals. Drawbacks of metals. Alloys- advantages of alloying-brass, bronze, steel, stainless steel, gold alloys, silver alloys and their uses.

Semiconductors: Elemental semiconductors- silicon, germanium. Doping- n-type and p-type semiconductors, p-n junctions, I-V characteristics- diode equation. Qualitative ideas of devices- diodes to ICs. Compound semiconductors. **16 hours**

**Unit II**

Polymers- Introduction, thermoplastics and thermosets, specific examples. Rubber- types of rubber. Vulcanization of rubber. Fibres- different types of natural and synthetic fibres. Resins, adhesives and polymer coatings. Physical, chemical, mechanical properties and applications of polymers. Recycling of polymers.

Composites- introduction, types. Wood, concrete, FRP and some advanced composites. Properties and applications. **16 hours**

**Unit III**

Ceramics- Introduction, classification, raw materials, fabrication methods, properties and applications. Types of ceramics- oxide and non-oxide ceramics. Allotropes of carbon- graphite, diamond and fullerene – structure dependent properties. Primary refractory materials.

Glasses- introduction, raw materials, manufacture of glass, properties and applications. Types of glasses, properties and applications. Photochromic and photosensitive glasses. **16 hours**

**References:**

1. The Physics of Materials: How Science Improves Our Lives, Solid State Sciences Committee, (National Research Council, 1997)
2. The Science of World Around Us, Solid State Sciences Committee, (National Research Council, 2007)
3. Materials Science and Engineering – V Raghavan (Prentice Hall India, 1993)
4. Introduction to Solids – A J Dekker (McMillan India, 1981)
5. Plastics-How Structure Determines Properties – G Gruenwald (Hanser)
6. Understanding Materials Science – R E Hummel (II Ed.) (Springer, 1993)
7. Materials Science – Nagpal (Khanna, 1983)
8. Polymer Science – V R Gowarikar, N V Viswanath, Jayadev Sridhar (Wiley Eastern, 1987)
9. Composite Materials Engineering & Science – F L Mathews & R D Rawlings (Chapman & Hall, 1990)
10. Introduction to Ceramics – W D Kingery, H K Bower and U R Uhlman (John Wiley, 1960)
11. Glasses and Vitreous State – J Zarzycki (Cambridge University Press, 1982)

**Course II: 4 Credits**

**MSPGD 402: Principles of Crystal Structure Analysis**

**Objectives:** This course serves as a basic foundation for the Post Graduate Diploma in Materials Science programme. It aims to (i) develop an understanding of how the behaviour/properties of materials are intricately connected to their structure and the type of bonding at the atomic level (ii) correlate the relationship between the atomic structure and crystal energy leading to changes in properties.

**Expected course outcomes:** On completing this course, the students will be able to (i) analyze the key concepts of structure and bonding in covalent, ionic, metallic, and coordination compounds. (ii) relate the fundamentals with the structure property correlations in materials. (iv) apply XRD techniques to identify the crystal structure, lattice parameter and purity of materials.

**Unit I**

Structure and Formation of Materials: Brief history of Materials Science, Condensed state of matter-crystalline and amorphous states. Bonding in Materials: Ionic bond - Lattice energy - Madelung constant. Covalent, metallic and molecular bonds. Bond angle, bond length and bond energy – simple problems. Hybridisation - Correlation between bonds and physical properties. Simple crystal structures - Sodium Chloride, Cesium Chloride, Diamond and Zinc sulphide structures. Close-packed structures in two and three dimensions. **16 hours**

**Unit II**

Crystal Geometry: Crystal structure – lattice and basis, primitive and non-primitive unit cells. Variation from periodicity - Quasi crystals. Crystal morphology - symmetry elements - Crystal systems in two and three dimensions. Point group symmetry . Space groups and Bravais lattices. Crystal planes and directions -Miller indices - interplanar separations – related problems. **16 hours**

**Unit III**

Structure analysis by X-rays – The electromagnetic spectrum –MW, IR, Visible, X-rays, γ-rays – applications in the different frequency range. X-rays – production. The X-ray spectra characteristic and continuous radiation. X-ray diffraction- Bragg's law. Atomic scattering factor. Laue conditions for diffraction and Bragg's law – Lattice and Geometrical structure factor - systematic absences – sc, bcc, fcc, NaCl and diamond structure. Laue, Rotation and Powder methods of X-ray analysis. **16 hours**

**References:**


1. Elements of Materials science and Engineering – Lawrence H van Vlack (Pearson, Delhi 2014)
2. Materials Science and Engineering – V Raghavan (PHI Learning Pvt. Ltd.,New Delhi 2010)
3. The Structure and Properties of Materials-Vol.I-IV- Rose, Shepard and Wulff (Wiley easterrn, 1987)
4. The Nature of Chemical Bond – L Pauling (Oxford & IBH, 1960)
5. Introduction to solids – L V Azaroff (Tata McGraw Hill, Bombay 1986)
6. X-Ray Crystallography – M J Buerger (John Wiley, 1942)
7. Introduction to Solids – A J Dekker (McMillan India, 1981)
8. Solid State physics – R L Singhal (Kedarnath Ramnath, 1988)


**Course III: 4 Credits**

**MSPGD 403: Mechanical Behaviour of Materials**

**Objectives:** The objectives of this course are to (i) explain different types of crystal imperfections and their importance in determining the mechanical behaviour of materials (iii) describe the elastic and plastic deformations in various materials (iv) explain fracture in materials including ductile and brittle fracture.

**Expected course outcomes:** At the end of this course, students will be able to

(i) classify defects in materials and their connection with elastic and plastic deformations (ii) correlate the mechanical properties with the nature of bonding in materials. (iii) identify the conditions under which materials fail (iv) apply this knowledge to select appropriate materials for various applications in industries and research

**Unit I**

Crystal defects: Introduction to defects- Point and line defects -- Schottky and Frenkel defects - equilibrium concentrations. Line imperfections - edge and screw dislocations - Buerger's vector in cubic crystals. Surface imperfections - grain boundary, tilt and twin boundaries.

Deformation of a material: Types of deformation, temporary deformations, permanent deformations. Elastic behaviour of materials: atomic model of elastic behaviour - modulus as a parameter in design - rubber-like elasticity - anelastic behaviour - viscoelastic behaviour. **16 hours**

**Unit II**

Plastic Deformation in Crystalline Materials: The tensile stress-strain curve – different types of plastic deformation, slip and twinning - Plastic deformation by slip - the shear strength of perfect and real crystals - CRSS - the stress to move a dislocation. Effect of temperature on plastic deformation. Strengthening against plastic deformation – strain hardening – grain refinement – solid solution – precipitation strengthening. Creep in crystalline materials - mechanism of creep and creep resistant materials. **16 hours**

**Unit III**

Fracture in metals and ceramics –introduction, ductile fracture, ductile-brittle transition, brittle fracture- Griffith theory. Compressive and tensile strength - size effect, stress intensity factor, toughness measurements. Protection against fracture. Fatigue failure - characteristic of fatigue failure - statistical nature of fatigue - correlation of fatigue strength and plastic properties. Factors affecting fatigue strength.

Introduction, wear of metals–mechanisms, factors influencing wear, wear resistance-protection against wear. ASTM number and their significance. Polymer rheology, measurement of rheological parameters by capillary rotating, parallel plate cone plate rheometer. **16 hours**

**References:**


1. Elements of Materials Science and Engineering – Lawrence H van Vlack (Addision Wesley, 1975)
2. Materials Science and Engineering – V Raghavan (Prentice Hall,1993)
3. Materials Science and Processes – B S Narang (CBS,1983)
4. Introduction to Solids – L V Azaroff (McGraw Hill, 1960)
5. Introduction to Solid State Physics – C Kittel (II Ed. Asia publishing House, 1965)
6. The Structure and Properties of Materials Vol I-IV – Rose, Shepard and Wulff (Wiley Eastern, 1987)
7. Physical Metallurgy – V Raghavan (Printice Hall, 1989)
8. Materials Science and Metallurgy – O P Khanna (Dhanpat Rai & Sons, 1984)
9. Introduction to Properties of Materials – Daniel Rosenthal and Robert M Asimow (Affiliated East-West Press, 1974)
10. Physical Metallurgy – S H Avner (Tata McGraw-Hill, 1997)
11. Mechanical Metallurgy – George R Dieter (McGraw-Hill, 1988)
12. Structure and Principle of Engineering Materials – V S R Murthy (Tata McGraw Hill- 2003)

13. Principles of Polymer Science – Bahadur P, Sastry N V (Narosa, 2005).

**Course IV: 4 Credits**

**MSPGD 404: Materials for Sustainable Energy**

**Objectives:** Objective of the course is to impart a basic knowledge about (i) global energy scenario and energy consumption in various sectors (ii) highlight the necessity for materials for renewable energy sources and energy production (iii) efficient energy production using solar cells, fuel cells, biomaterials (iv) conversion of various biomass feedstock to bioenergy/biofuel production

**Expected course outcomes:** The students should gain knowledge on (i) global energy scenario such as production and consumption by various sectors and the need for finding efficient and renewable energy sources (ii) the various sources of energy such as solar power, hydrogen energy and bio materials (iii) how solar power may be efficiently harnessed using solar cells (iii) the basic working principles of hydrogen and fuel cells (iv) biomaterials as a cheap and sustainable energy resource (iv) the use of energy resources effectively and efficiently

**Unit I**

Global Energy Scene: Energy consumption in various sectors, projected energy consumption for the next century, Definition and units of energy, power, Forms of energy, Conservation of energy, Second law of thermodynamics. Solar Cells – Photovoltaic effect- light absorption- carrier generation and recombination,p-n junction: homo and heterojunctions, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics; solar cell- Efficiency limits; Variation of efficiency with band-gap and temperature- Efficiency measurements-High efficiency cells. Types of Solar Cells. Batteries- sustainable materials for battery technology – sodium ion battery. **16 hours**

**Unit II**

Hydrogen energy – merits as a fuel – production of hydrogen – fossil fuels, electrolysis, thermal decomposition, photochemical and photocatalytic methods. Fuel cells – introduction – difference between batteries and fuel cells, components of fuel cells, principle of working of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages of fuel cell power plant. Types of fuel cells - Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC) Polymer Electrolyte fuel cells. Application of fuel cells – Recent developments-commercially available fuel cells. **16 hours**

**Unit III**

Biomaterials for energy: Introduction. Classification and properties of biomass- Biomass characterisation, different energy conversion methods, Bio Energy and biomass resources – classification, Physico-chemical characteristics. Biomass Combustion, Biomass-based power generation. Biofuels - Bioethanol production from lignocelluloses, waste material, including crop residue, sugar and starch; biodiesel production from vegetable oil and animal fat, environmental impacts of biofuels; biofuel blends; green diesel from vegetable oil; biodiesel production process, by-product utilisation. Production of biohydrogen- production of hydrogen by fermentative bacteria. **16 hours**

**References:**

1. Fuel Cell Systems Explained, 2nd Edition- J Larminie and A Dicks (Wiley, 2003)
2. Principles of Fuel Cells- Xianguo Li (Taylor and Francis, 2005)
3. Fuel Cells: From Fundamentals to Applications- S Srinivasan (Springer, 2006)
4. Fuel Cell Fundamentals- O'Hayre, S W Cha, W Colella and F B Prinz, (Wiley, 2005)
6. Solid State Devices – Ben G Streetman and Sanjay Banerjee (Prentice-Hall, 2000)
5. High efficiency silicon Solar Cells – M A Green (Tran. tech., 1987)
7. Solar Cells: Materials, Manufacture and Operation, eds. Tom Markvart, Luis castaner, (Elsevier, 2010)
8. Solar Voltaic Cells, Johnston W D (Marcel Dekker, 1980)
9. Mutha, V. K. (2010). Handbook of bioenergy and biofuel SBS Publishers, Delhi
10.Clark, J. H., & Deswarte, F. (Eds.). (2014). Introduction to chemicals from biomass. John Wiley & Sons.
11. Klass, D. L. (1998). Biomass for renewable energy, fuels, and chemicals. Elsevier.

## II SEMESTER

**Course VI: 4 Credits**

**MSPGD 451: Advanced Functional Materials**

**Objectives:** This course aims to (i) provide the idea of new materials and technologies in current science and research including shape memory alloys, conducting polymers and nanomaterials. (ii) introduce the properties, synthesis, processing, and applications of new materials(iii) instil in the students the urge to explore newer materials for modern-day challenges in science and technology.

**Expected course outcomes:** At the end of the course, students will be able to (i) discuss on new technology materials and their properties. (ii) distinguish the characteristic properties of polymers vs conducting polymers, and bulk vs nanomaterials. (iii) apply the synthetic techniques for conducting polymers and nanoparticles in their laboratory. (iv) apply the knowledge of the design of materials for new technologies and develop an interest in research in the field of materials science. (v) find equal opportunities in polymer, nanotechnology industries and also as researchers in universities/institutes.

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**Unit I**

Smart Materials: Introduction to smart materials – shape memory effect (SME) and martensitic transformation, SME related changes in material properties, SME and Superelasticity. Ti - Ni SM Alloys – Effect of thermal and mechanical cycling. Cu - based SM Alloys. Ferrous SM alloys. Fabrication of SM Alloys. Characteristic fundamental properties- Shape memory ceramics and polymers. General applications of Smart materials – design of actuators, robotics, drones, medical, applications. **16 hours**

**Unit II**

Conducting Polymers: Introduction to conducting polymers. Polyacetylene. Structural features – factors affecting conductivity of polymers - semiconducting, superconducting. Preparation of conducting polymers – doping. Band structures of polymers – charge transport in conducting polymers, nature of charge carriers - soliton, polaron, bipolarons. Models of charge transport – structure-property relationship. Applications of conducting polymers– electronic, electrochemical, photonic, sensors, and medical applications. **16 hours**

**Unit III**

Nano-materials: Introduction – nanostructural materials – metals, semiconductors and ceramics. Synthesis of nanoparticles– inert gas evaporation – laser pyrolysis –sputtering techniques, plasma techniques. Various chemical methods of synthesis. Unique properties of nanomaterials. Metal nanoparticles – electronic and optical properties – surface plasmon resonance. Functionalized metal nanoparticles–Semiconductor nanoparticles - synthesis, characterisation and applications of quantum dots – size dependent properties – Magnetic nanoparticles- assembly and nanostructures. Carbon nanotubes and fullerene as nanoclustures. **16 hours**

**References:**


1. The Science and Engineering of Microelectronic Fabrication-S A Campbell (2nd ed., Oxford Univerity Press,2012).
2. Intrinsically conducting polymers: An emerging technology- M Aldissi (editor), (Springer, 2010).
3. Quantum Chemistry Aided Design of Organic Polymers- J M Andre, J Delhalle & J L Bredas (World Scientific, 1991).
4. Electrical properties of polymers: Chemical principles- C C Ku and Leilpens (Hansen, 1987).
5. Science and applications of conducting polymers- W R Salaneck, D T Clark, E J Samuelson (Adam Hilger, 1991).
6. Special polymers for Electronics and optoelectronics- J A Chilton, M T Goosey, (Chapman and Hall, 1995).
7. Langmuir - Blodgett films - Gareth Roberts (Ed), (Oxford, 1989).
8. Chemistry of Advanced Materials- D. Chakravorty and A. K. Giri (C. N. R. Rao. Editor), (Blaclwell, 1992).
9. Physics and Chemistry of Small Clusters- P Jena, B K Rao and S N Khanna (edt). (Plenum Press, 1986).
10. Physics and Chemistry of Finite Systems: From Clusters to Crystals, (Kluwer, 1992).
11. Selection of Engineering Materials- G Lewis, (Prentice Hall, 1990).
12. Engineering Materials and their applications- R A Flinn and P K Trojan, (Jaico, 1998).
13. Fundamentals of Ceramics- M W Barsoum, (McGraw Hill, 1997).
14. Shape Memory Materials- K Otsuka and C W Wayman, (Cambridge, 1998).
15. Nanoscale Materials – (Ed) L M Liz-Marzan and P V Kamat, (Kluwer, 2003)
16. Nanostructured Materials and Nanotechnology (Ed)- H S Nalwa, (Academic Press, 1999).
17. An introduction to interfaces and colloids: The bridge to nanoscience- John Berg C (World Scientific Publishing C. Pvt.Ltd, 2009)
18. Conducting polymers: A new era in electrochemistry- Inzelt Gyorgy (springer, 2008)
19. Introduction to Nanotechnology- C P Poole and Frank J Owens (Wiley, 2006)
20. Shape Memory Alloys: Manufacture, Properties and Applications – H R Chen (Nova Science, 2010)


**Course VII: 4 Credits**

**MSPGD 452: Device Fabrication Technology**

**Objectives:** The key objectives are to (i) prioritize the requirement of vacuum technology for materials testing and characterization (ii) prepare the students with a strong foundation on thin film technology, its importance and applications. (iii) discuss various deposition techniques for the growth of thin films and their limitations. (iv) introduce the student to the fast expanding research on semiconductor technology within India and abroad (v) provide a fundamental knowledge of semiconductor device fabrication.

**Expected course outcomes:** By the end of this course, (i) students will be able to understand the importance of vacuum technology in materials characterisation (ii) the student will acquire the necessary skills for working in industries associated with vacuum technology and scientific instruments. (iii) the student will be able to correlate various deposition parameters and their effect on the structure and properties of the thin film. (iv) the student will be able to understand the processes in semiconductor device fabrication.

**Unit I**

Fundamentals of vacuum techniques: Basic concepts of pumping: Regions of gas flow - molecular and viscous flow. Conductance of a pipework, pipework in parallel and series - fundamental equation of vacuum technology. Vacuum pumps: operating limits of a pump. Rotary, vapour diffusion, turbomolecular, cryogenic- a brief survey of working principles. Vacuum measurement: thermal conductivity gauges, Pirani and thermocouple gauges, ionisation gauges, hot and cold cathode ionisation gauges - working principle. **16 hours**

**Unit II**

Thin Films: Definition of thick and thin films. Physical vapour deposition - thermal evaporation. - Knudsen cosine law. Sputtering- DC glow discharge and low-pressure sputtering. Reactive sputtering. Chemical vapour deposition. MBE, MOCVD, ALD methods of preparing device grade films. Spray pyrolysis and other chemical methods of film preparation for large area applications. LB films and their applications. **16 hours**

**Unit III**

Semiconductor device fabrication: Clean room-quality and safety protocols – gowning – clean room levels. Wafer preparation – Silicon – Contamination - Substrate cleaning methods – defects – Doping – diffusion - Fabrication of junctions - IC technology: masking and etching – lithography – optical, electron beam – photoresists - dry etch - wet etch**.** Nanofabrication. Process integration- photovoltaic cell, MOS capacitor, cantilever. Packaging of devices. **16 hours**

**References:**

1. Fundamentals of Vacuum Techniques - A Pipco et al (MIR, 1984)
2. Vacuum Technology - A Roth (North Holland Pub. Co., 1982)
3. Modern Vacuum Physics - Austin Chambers (Chapman and Hall, 2005)
4. Handbook of Thin Film Technology – L I Maissel and R Glang (Ed) (McGraw Hill, 1970)
5. Vacuum Deposition of Thin Films – L Holland (Wiley, 1956)
6. Thin Film Phenomena – K L Chopra (Mc Graw Hill, 1969)
7. Thin Film Technology and Applications – K L Chopra and L K Malhotra (Ed) (Tata Mc Graw Hill, 1985)
8. Semiconductor Physics – P S Kireev (MIR Publishers, 1978)
9. Physics of Semiconductors Devices – S M Sze (Wiley Eastern, 1991)

**COURSE VIII: 4 CREDITS**

**MSPGD 453: MATERIALS CHARACTERIZATION-I**

**Objectives**: The objectives of the course are i) to identify and describe the key components and working principles of both powder x-ray diffractometers and single crystal X-ray diffractometers. ii) to differentiate between crystalline and amorphous solid structures based on their X-ray diffraction patterns. iii) to explain the procedures for collecting and analyzing X-ray diffraction data for both powder and single crystal samples. iv) to comprehend the fundamental principles governing various imaging techniques, including optical microscopy, atomic force microscopy, and electron microscopy. v) to differentiate between the capabilities and limitations of different imaging techniques for material characterization at various scales. vi) understand the basic procedures for sample preparation for electron microscopy technique. vii) to introduce the fundamental principles behind various spectroscopic techniques, including UV-Visible-NIR, IR, Raman, Fluorescence, EDAX, and XPS. viii) to familiarize students with the instrumentation and experimental procedures involved in performing various spectroscopic measurements.

**Expected course outcomes**: By the end of this course, i) the student is able to operate a powder x-ray diffractometer by setting appropriate experimental parameters for data collection from various solid samples. ii) the student will interpret powder X-ray diffraction data to determine crystal structure parameters and quantify crystallinity in amorphous or semi-crystalline materials. iii) the student will identify and describe the key components of AFM, SEM, TEM systems and discuss their diverse applications in material science, biology, and nanotechnology. iv) the student will analyze and interpret micrographs obtained from SEM and TEM to deduce information about surface morphology, elemental composition, grain structure, and crystal defects. v) the student will be able to select appropriate spectroscopic methods: choose the most suitable spectroscopic technique(s) for solving specific analytical problems based on the nature of the sample and the information required.

**Unit I**

Structural characterization of solid materials: Structure analysis by X-rays – Powder X-ray diffractometer- instrumentation, working principle, collection and analysis of data for crystalline and amorphous samples. Single crystal X-ray diffractometer- instrumentation, working principle, collection of data and analysis. Low temperature requirements. **16 hours**

**Unit II**

Imaging techniques: Advantages and limitations of optical microscopy, metallurgical microscope, Atomic force microscope- working principle, modes of operation, applications, Electron microscopy- SEM, TEM- working principle- instrumentation- sample preparation-applications.

**16 hours**

**Unit III**

Spectroscopic methods: UV-Visible-NIR spectroscopy, absorption-transmission-reflectance measurements, IR spectroscopy- Raman spectroscopy-applications, NMR spectroscopy-1H, 13C, Fluorescence spectroscopy, EDAX, XPS. **16 hours**

**Reference**


1. Elements of X-ray diffraction, B D Cullity, Addison-Wesley, 1978.
2. Atomic force microscopy, G. Haugstad, Wiley, 2012.
3. X-Ray crystallography, M J Buerger, John Wiley, 1942
4. Physical principles of electron microscopy- Second edition, R. F. Egerton, Springer, 2016.
5. Introduction to properties of materials – D. Rosenthal and R. M.Asimow, Affiliated East-

West Press, 1974
6. Scanning electron microscopy and X-ray micro analysis- J. I Goldstein, D. E Newbury, D. C Joy, C.E Lyman, P. Echlin, E.Lifshin, L. Sawyer and J.R.Michael, Springer, 2007.
7. The principles and practice of electron microscopy: Ian M Watt, Secondedition, Cambridge Univ. Press, 2003
8. Fundamentals of molecular spectroscopy, C. Banwell and E. McCash, Sixth Edition, Springer, 2024.
9. Spectroscopy, D. L. Pavia, Cengage learning India Pvt. Ltd., 2007.
10. Handbook of X-ray photoelectron spectroscopy, J. F.Moulder, W. F. Stickle, P. E. Sobol, K. D. Bomben, Perkin-Elmer Corporation, 1992.

**Course IX: 4 Credits**
**MSPGD 454: Materials Characterization-II**

**Objectives**: The objectives of the course are, i) to explain the basic principles of electrical measurement, including units, standards, and the operation of common instrumentation. ii) to develop skill and proficiency in performing and analyzing common DC/AC electrical measurements and cyclic voltammetry for material characterisation. iii) to explain the physical principles behind various thermal analysis techniques, including mass change, heat flow, and dimensional changes as a function of temperature or time. iv) to correlate thermal analysis results with the structure, composition, and processing of various materials. v) to understand the basic principles underlying various mechanical testing methods and their significance in material characterization. vi) to comprehend the importance of proper sample preparation and standardized testing procedures to ensure accurate and reproducible results.

**Course Outcomes**: The student will be i) able to explain the working principles of basic electrical measurement instruments such as multimeters, power supplies, and source measurement units. ii) able to perform accurate two-probe and four-probe (Kelvin) resistance measurements and analyze current-voltage (I-V) characteristics of various materials and devices. iii) able to extract quantitative parameters from I-V, impedance, C-V, and cyclic voltammetry data using appropriate analytical methods. iv) able to analyze and interpret experimental data obtained from TGA, DSC, and TMA curves to extract meaningful material properties and behavioural insights. v) able to outline the standard procedures for preparing test samples for tensile, compression, and hardness tests, and explain the steps involved in conducting these tests. vi) analyze stress-strain curves to determine material properties such as Young's Modulus, yield strength, ultimate tensile strength, ductility, and toughness for different materials.

**Unit I**
Electrical measurements: Basics of instrumentation- DC measurements- I-V characteristics, Van der Pauw method- Hall effect, AC measurements- Impedance spectroscopy- Capacitance-Voltage profiling, Cyclic voltammetry-potentiostatic/ Galvanostatic cycling. **16 hours**
**Unit II**
Thermal characterization: Thermal analysis- instrumentation, thermobalances, thermocouples, thermogravimetric analysis- differential scanning calorimetry, thermomechanical analysis, thermal conductivity and heat capacity measurements. **16 hours**
**Unit III**

Mechanical testing of materials: Tensile – compression – bending – shear testing of different materials, Instrumentation- Sample preparation- analysis- Universal testing machine, Hardness testing machine, Hardness numbers, Impact testing. **16 hours**

**Reference**


1. Electronic properties of materials – Hummel, FourthEdition,Springer,2011
2. Electronic materials and devices – D. K. Ferry, Academic Press, 2001
3. Electrical properties of materials, L. Solymar, D. Walsh, R. R. A. Syms, Oxford publishers, 2018.
4. An introduction to thermal analysis: techniques and applications, M. E. Brown, Kluwer academic publishers, 2001.
5. Thermal methods of analysis- principles, applications and problems, P. J. Haines, Springer, 1995.
6. Plastics-How structure determines properties- G Gruenwald, Hanser, New York 1992.
7. Mechanical testing of materials, E. Gdoutos, M. Konsta-Gdoutos, Springer, 2024.
8. Testing of metallic materials – A V K Suryanarayana, BSP Books Pvt. Ltd.,2018


**MSPGD 405: Practicals-I & MSPGD 455: Practicals-II**

**Objectives of the courses:** The laboratory courses are designed to (i) impart hands on experience on the measurement of all aspects of the science of materials, such as their structure and their thermal, electrical, chemical and mechanical behaviour (ii) expose the students to various measurement skills (iii) impart better understanding of the principles of the measurement techniques as well as the material properties.

**Expected course outcomes**: The students (i) gain an understanding of the techniques used as well as the properties studied in each experiment (iii) gain basic skills to work in research field/industries (iv) gain confidence and are better prepared to face job interviews

**Course V: 4 Credits**

**MSPGD 405: Practicals-I**

1. Thermistor Thermometer
2. Thermal Conductivity of Insulators
3. Analysis of Bronze/**Brass**
4. Energy band gap in p-n junctions
5. Young's modulus of glass/polymer
6. Creep in materials
7. Conductivity of ionic salts
8. Poisson's ratio of rubber
9. Corrosion studies
10. Estimation of Cr and Ni in stainless steel by spectrophotometry
11. Glass transition temperature
12. Study of shape memory alloys
13. Solar cell I-V characteristics
14. Metallurgical Microscope – Grain Size Measurements
    a) Ferrous alloys b) Non-ferrous Alloys
15. Energy gap measurement using UV-vis spectrophotometry

**COURSE X: 4 CREDITS**

**MSPGD 455: Practicals-II**

Data collection/analysis of the materials using the following characterization methods.

1. UV-Visible absorption/transmission/reflectance measurements.
2. IR spectrum.
3. Crystal structure analysis from X-ray diffractogram.
4. Atomic force microscopy.
5. Scanning electron microscopy.
6. Transmission electron microscopy.
7. Thermogravimetric analysis.
8. Differential scanning calorimetry.
9. Universal testing machine.
10. Hardness and impact tests.
11. Cyclic voltammetry.
12. I-V characteristics.
13. Impedance analysis.
14. Viscosity measurements.
15. Preparation and characterization of metal/metal oxide nanoparticles.