MATERIALS

UG INSTRUCTORS

Avadhani G. S., Anup Mandal

MATERIALS CORE CURRICULUM

SEMESTER 4 (JANUARY)

UMT 202: STRUCTURE OF MATERIALS (2:1)
(CORE FOR MATERIALS MAJORS AND MINORS)

Elements of bonding, structures of simple metallic, ionic and covalent solids; Coordination polyhedra, projections of structures, stacking; Lattices, symmetry operations, stereographic projection; Structure and thermodynamics of point defects and solid solutions, non-stoichiometry, ordered structures; Dislocations and slip, twinning and interfaces.

INSTRUCTORS: N. Ravishankar and S. Karthikeyan

SUGGESTED BOOKS:

1. Kelly, A. and Groves, G. W., Crystallography & Crystal Defects, Addison Wesley
2. Barrett, C.S. and Massalski, T. B., Structure of Metals, Pergamon
3. West, A. R., Introduction to Solid State Chemistry, John Wiley

UMT 203: MATERIALS THERMODYNAMICS (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS

First law, enthalpy, thermochemistry; Second law, entropy, statistical interpretation; Helmholtz and Gibbs free energies, chemical potential; Solution thermodynamics; Conditions for equilibrium, phase rule, phase diagrams; Chemical reactions and equilibria; Surfaces and interfaces

INSTRUCTORS: T. A. Abinandanan

SUGGESTED BOOKS

1. DeHoff, R.T. 2006. Thermodynamics in Materials Science, Taylor & Francis
2. Gaskell, D. R. 2003. Introduction to the Thermodynamics of Materials (4th Ed), Taylor & Francis

UMT 205: MECHANICAL PROPERTIES OF MATERIALS (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Structures, vector mechanics (statics) and types of loads; Introductory concepts in stress and strain and their transformation; Linear elasticity in single and poly-crystals and in amorphous solids; Stresses in constrained systems – thermal and misfit stresses; Viscoelasticity and hyperelasticity in polymers; Stress concentration; Fracture mechanics and toughening mechanisms; Introduction to plastic deformation; Uniaxial stress-strain curve and flow instabilities; Effect of strain, strain-rate and temperature of flow stress; Continuum-based yield criteria; Plastic deformation mechanisms – slip, twinning and diffusion; Introduction to dislocation theory – slip systems, critical resolved shear stress, strengthening mechanisms; Creep and fatigue.

INSTRUCTOR: S. Karthikeyan

SUGGESTED BOOKS:

1. Beer, F. P., Johnston, E. R., DeWolf, J. T., and Mazurek, D.F. 2014. Mechanics of Materials, 7th edition, McGraw Hill
2. Hosford, W. 2010. Mechanical Behavior of Materials, 2nd edition, Cambridge University Press
3. Courtney, T. H. 2001. Mechanical Behavior of Materials, 2nd edition, Tata McGraw Hill
4. Ward, I. M. and Sweeney, J. 2012. Mechanical Properties of Solid Polymers, 3rd edition, Wiley

SEMESTER 5 (AUGUST)

UMT 301: MATERIALS KINETICS (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Point defects, Fick's laws of diffusion, concept of jump frequency, activation energy, Kirkendall effect, solidification, nucleation, constitutional supercooling, sintering, interfaces, grain growth, solid state transformations, JMA theory, GP zone, Spinodal decomposition, ordering and martensitic transformations, effect of stress and electric current.

INSTRUCTORS: Aloke Paul and C. Srivastava

SUGGESTED BOOKS:

1. Reed-Hill, R. E. and Abbaschian, R. 2009. Physical Metallurgy Principles, Cengage
2. Porter, D. A. and Easterling, K. E. 2009. Phase Transformations in Metals and Alloys, Taylor and Francis

UMT 302: INTRODUCTION TO MATERIALS PROCESSING (2:1)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

1. **UMT 302** (2:0) INTRODUCTION TO MATERIALS PROCESSING
   Instructor: Surendra Makineni

2. **UMT xxx** (0:1) MATERIALS PROCESSING LAB (course numbering to be assigned)
   Instructor: Surendra Makineni and R.J. Deshpande

Metals: Principles of extraction of metals, mineral beneficiation, hydrometallurgy, electrometallurgy, pyrometallurgy.

Ceramics: Synthesis of ceramic powders, consolidation, sintering.

Polymers: Introduction to polymer science and engineering, polymer synthesis, introduction to polymer processing.

SUGGESTED BOOKS:

1. Alcock, C. B. 1976. Principles of Pyrometallurgy, Academic Press, London
2. Venkatachalam, S. 1998. Hydrometallurgy, Narosa, New Delhi
3. Kingery, W. D., Bowen, H. K. and Uhlmann, D. R. 1976. Introduction to Ceramics, Wiley
4. Billmeyer, F. W. Textbook of Polymer Science
5. Gowarikar, V. R., Vishwanathan, N. V. and Sreedhar, J., Polymer Science

UMT 312: MECHANICAL TESTING AND FAILURE OF MATERIALS (2:1)
(CORE FOR MATERIALS MAJORS)

1. **UMT 312** (2:0) MECHANICAL TESTING AND FAILURE OF MATERIALS
   Instructor: S. Karthikeyan

2. **UMT xxx** (0:1) MECHANICAL TESTING LAB (course numbering to be assigned)
   Instructor: S. Karthikeyan and R. Ravi

Overview of solid mechanics, Overview of deformation and failure mechanisms in metals, ceramics and polymers, Mechanical testing techniques: Tensile and compression, hardness, fatigue, impact, creep, fracture, Introduction to instrumentation, controls and data acquisition.

SUGGESTED BOOKS:

1. Hosford, W. 2010. Mechanical Behavior of Materials, 2nd edition, Cambridge University Press
2. Courtney, T. H. 2001. Mechanical Behavior of Materials, 2nd edition, Tata McGraw Hill
3. Ward, I. M. and Sweeney, J. 2012. Mechanical Properties of Solid Polymers, 3rd edition, Wiley

SEMESTER 6 (JANUARY)

UMT 309: FUNCTIONAL PROPERTIES OF MATERIALS I (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Brief review of the fundamentals of quantum mechanics, statistical mechanics, electrostatics and electrodynamics; Energy bands in crystals, density of states, electric conduction in metals and alloys, thermoelectric phenomenon and applications, semiconductors and devices, electrical properties of polymers, ceramics, dielectric and amorphous materials, classical and quantum mechanical description

of optical properties, lasers, LEDs, photonics, magnetic phenomenon and applications, thermal properties of materials.

INSTRUCTOR: B. Sahoo

SUGGESTED BOOKS:

1. Kittel, C., Introduction to Solid State Physics, McGraw-Hill
2. Solymar, L. and Walsh, D., Lectures on Electrical Properties of Materials
3. Omar, M. A., Elementary Solid State Physics
4. Hummel, R. E., Electronic Properties of Materials
5. Hench, L.L, West, J.K. 1990. Principles of Electronic Ceramics, Wiley
6. West, A.F., Solid State Chemistry and its Applications, Wiley (2nd ed.)

UMT 310: INTRODUCTION TO MATERIALS MANUFACTURING (2:1)
(CORE FOR MATERIALS MAJORS)

Processing of metallic materials: Principles of hot, warm and cold working of metallic materials; Fundamentals of metal forming processes – rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Introduction to metal casting and joining; Powder processing of metallic and ceramic materials: Powder production, compaction and sintering

Polymer processing: Basic concepts of compounding and processing; concept of master batches; classification and type of additive for plastics: antioxidants, light stabilizers, UV stabilizers; Processing techniques: Basics of various processing techniques, Extruders: single screw and twin screw extruders, film blowing, fiber spinning, thermoforming; Molding: Injection molding, blow molding, compression molding, injection stretch blow molding, gas and water assisted injection molding

INSTRUCTORS: S. Suwas, S. Bose and G. S. Avadhani

SUGGESTED BOOKS:

1. Grover, M. P. 2011. Introduction to Manufacturing Processes, Wiley
2. Dieter, G. E. 1988. Mechanical Metallurgy, McGraw-Hill
3. Billmeyer, F. W. Textbook of Polymer Science, 3rd Edition
4. Gowarikar, V. R., Vishwanathan, N. V. and Sreedhar, J., Polymer Science

UMT 311: FUNCTIONAL PROPERTY CHARACTERIZATION LABORATORY (0:1)
(CORE FOR MATERIALS MAJORS)

Resistivity measurement by different methods, four probe method, determination of B-H curve, Curie point measurement Hall effect experiment, magnetostriction measurement, measurement of dielectric constant as function of temperature, Seebeck effect, efficiency of solar Cell

INSTRUCTOR: S. Dasgupta

SEMESTERS 7 (AUGUST)

UMT 401: FUNCTIONAL PROPERTIES OF MATERIALS II (3:0) (CORE FOR MATERIALS MAJORS)

Crystal chemistry, point defects and associated thermodynamic equilibria, microstructural control (texture, porosity and grain size), energy levels (band structure in metals and semiconductors, junctions, electrical double layers), thermodynamic relationships, symmetry dependence and tensorial representation of properties; Introduction to properties: dielectric (piezoelectric, ferroelectric, pyroelectric), magnetic (ferro-, ferri-, magnetostriction), electrical conductivity (ionic and electrical), thermoelectricity; Specific examples of systems: piezoelectric, ferro-electric and -magnetic materials (domain structure, poling, influence on endurance, soft and hard materials), Actuator materials, Energy conversion devices (common batteries, fuel cells, supercapacitors)

INSTRUCTOR: V. Jayaram

SUGGESTED BOOKS:

1. Kingery, D.W., Bowen, H.K., Uhlmann, D.R, Introduction to Ceramics, Wiley (2nd Ed.)
2. Solymar, L. and Walsh, D. Electrical Properties of Materials, Oxford University Press (8th ed.)
3. Newnham, R.E. 2004. Properties of Materials, Oxford University Press
4. Hench, L.L, West, J.K. 1990. Principles of Electronic Ceramics, Wiley
5. West, A.F., Solid State Chemistry and its Applications, Wiley (2nd ed.)

SEMESTERS 8 (JANUARY)

UMT 400: BACHELOR OF SCIENCE (RESEARCH) PROJECT (0:13)
INSTRUCTORS: Faculty from Department of Materials Engineering OR Materials Research Centre

MATERIALS ELECTIVES

Materials majors are required to credit 52 materials credits (28 Materials core credits + 13 project credits + 11 materials elective credits). All graduate-level courses offered by Department of Materials Engineering (MT) and Materials Research Centre (MRC) count towards elective credits. However, the following list of courses offered by MT and MRC are deemed appropriate for undergraduate students, and thus recommended. Also indicated in parenthesis is the recommended year appropriate for the course.

MT209: Defects in Materials (3rd or 4th)
MT260: Polymer Science and Technology (3rd or 4th)
MR303: Nanomaterial Synthesis and Devices (3rd or 4th)
MR306: Electron Microscopy in Materials Characterization (3rd or 4th)
One of the following:

MT271: Introduction to Biomaterials Science and Engineering (3rd or 4th), or
MR203: Introduction to Biomaterials (3rd or 4th)*

MT201: Phase Transformations (4th)
MT231: Interfacial Phenomena in Materials Processing (4th)
MT256: Fracture (MT) (4th)
MT255: Solidification Processing (MT) (4th)
MT248: Modeling and Simulations in Materials Engineering (4th)
MR308: Computational Modeling of Materials (4th)

In addition, the following courses offered outside MT and MRC can also be considered towards materials elective credits.

IN232: Concepts in solid state physics (3rd or 4th)
One of the following:
NE201: Micro and Nano Characterization Methods (3rd or 4th),or
IN201: Analytical Instrumentation (3rd or 4th)*
NE241: Materials Synthesis: Quantum Dots To Bulk Crystals (3rd or 4th)
SS205: Symmetry and Structure in the Solid State (3rd or 4th)
ME 251: Biomechanics (4th)
ER206: Transport Phenomena in Energy systems (4th)
IP323: Topics in Basic and Applied Electrochemistry (4th)
PH351: Crystal Growth, Thin Films and Characterization (4th)
One of the following:
NE205: Semiconductor Devices and Integrated Circuit Technology (4th),or
IN214: Semiconductor Devices and Circuits (4th),or
E3 282: Basics of Semiconductor Devices and Technology (4th), or
IN 224: Nanoscience and Device fabrication (4th)*
NE310: Photonics technology: Materials and Devices (4th)
PD202: Elements of Solid and Fluid Mechanics (4th)
ME273: Solid and Fluid Phenomena at Small Scales (4th)

* Only one of two (or four) courses will count towards materials elective credits. For instance, if you credit both MT271 and MR203, only one of them will count towards materials elective, the other will count as a non-materials elective.