ESE-835 Materials Science and Engineering

Description

1. Energy systems engineering is a broad field encompassing energy storage systems alternative energy technologies, environmental compliance, energy efficient building, etc.
2. Students from multidisciplinary background are selected for MS ESE program, hence it is essential to impart basic knowledge related to materials science and engineering for effective research in energy materials.
3. The courses being offered in energy systems engineering department aim to train students to become outstanding researchers and professionals. To fulfill the objective, students must possess sound knowledge about fundamental characteristics of a variety of materials including metals, ceramics, polymers, semiconductors, etc.
4. This engineering course presents a broad multidisciplinary approach to understand and manipulate the electrical, optical, thermal and magnetic properties of materials and their applications in energy systems.
5. This course is proposed as an elective course for MS Energy Systems Engineering, MS Thermal Energy Engineering and MS Electrical Engineering (Power).
6. Various lab facilities for materials research are available at USPCASE, e.g. advance energy materials lab, energy storage lab, biofuel lab, solar lab, synthesis lab, etc. This new course will impart necessary basic knowledge to effectively utilize these facilities for quality research.

Educational Objectives

The objectives of this “Materials Science and Engineering” course are:

7. To equip students with the necessary materials science and engineering knowledge, skills and understanding to pursue successful careers in both industrial and research environments.
8. To describe the foundations and energy applications of materials science for engineering students as predicated upon the structure-processing-properties paradigm.

9. To provide knowledge on how the physical properties of metals, ceramics polymers and composites are correlated with their internal structures (on atomic, molecular, crystalline, micro- and macro- scales) and operational conditions (mechanical, thermal, chemical, electrical and magnetic).

Outcomes

10. The students will be given broad knowledge of properties and applications of various materials for energy applications, to produce quality materials scientists and good material researchers and engineers for industry.

Course Contents

Detailed Course Contents of the course are:

No.	Topics	Text Book	Contact Hours
1	**Introduction and significance of materials science and engineering for energy applications** • What is materials science and engineering • Classification of materials based on function and structure • Material design and selection for energy applications	A, B	3
2	**Atomic structure, arrangement and imperfections** • Bonding and arrangement, binding energy and interatomic spacing • Ionic arrangements, crystal structure and diffraction • Imperfections in atomic and ionic arrangements, defects and dislocations • Atoms and ions movement in materials	A, B	8

3	**Phase diagrams, phase transformations and heat treatment** • Phase rule and phase diagrams, solid solubility, isomorphous phase diagrams, relationship between properties and phase diagrams, diffusion in solids. • Three stages of annealing, Control of annealing, annealing and material processing • Principles of solidification, nucleation, controlled nucleation, growth mechanisms, solidification time and dendrite size, cooling curves, solidification defects, microstructural evolution, aging temperature and time, Aging procedures.	A,C	10
4	**Properties of materials** • Electronic and electrochemical properties of materials • Magnetic properties • Mechanical properties • Thermal properties	A,B,C	10
5	**Materials for energy applications** • Materials for renewable energy applications Semiconductor materials in solar cells, polymers and composites used in 3rd and 4th generation solar cells, construction materials for energy efficient building, alloys, carbon fibres and glass fibres for wind turbines, • Materials for thermal applications Alloys and coatings for gas turbines, thermal barrier coatings, materials for thermal	C, D	14

	reforming applications, materials for thermal power plants. • Materials for electrical applications Polymers and composites used in insulation systems and microelectronics, electronic materials and magnetic materials.		
	Total		45

11. Details of lab work, workshops practice (if applicable). N/A

12. Recommended Reading (including Textbooks and Reference books).

S. No.	Title	Author(s)	Assigned Code	Remarks
1.	The Science and Engineering of Materials	Donald R. Askeland Sixth Edition	A	Text
2.	Materials Science and Engineering: An Introduction	William D. Callister, Jr Eighth Edition	B	Text
3.	Ceramics for environmental and energy applications	Aldo Bocaccani, Ceramic transaction Volume 217	C	Text
4.	Energy Materials	Duncan W. Bruce, Dermot O'Hare , Richard I. Walton Wiley	D	Text
5.	Introduction to materials science for engineers	William F. Smith 6th Edition	E	Ref
6.	Ceramic Materials: Science and Engineering	C. Barry Carter and M. Grant Norton	F	Ref
7.	Phase transformations in metals and alloys	David A. Porter	G	Ref

8.	Technology of Engineering Materials	M.Phillip, W. Bolton	H	Ref