Materials Science and Engineering Course Descriptions

CORE COURSES

MSEN 5310 Thermodynamics of Materials (*3 semester hours*) Work, energy and the first law of thermodynamics; the second law of thermodynamics, thermodynamic potentials, the third law of **thermodynamics**, thermodynamic identities and their uses, phase equilibria in one-component systems, behavior and reactions of gases. Solutions, binary and multicomponent systems: phase equilibria, materials separation and purification. Electrochemistry. Thermodynamics of modern materials. (3-0) R

MSEN 5360 Materials Characterization (*3 semester hours*) Survey of atomic and structural analysis techniques as applied to surface and bulk materials. Physical processes involved in the interaction of ions, electrons and photons with solids; characteristics of the emergent radiation in relation to the structure and composition. (3-0) R

MSEN 6319 (EE 6319) Quantum Mechanics for Materials Scientists (*3 semester hours*) Quantum-mechanical foundation for study of nanometer-scale materials. principles of quantum physics, stationary-states for one-dimensional potentials, symmetry considerations, interaction with the electromagnetic radiation, scattering, reaction rate theory, spectroscopy, chemical bonding and molecular orbital theory, solids, perturbation theory, nuclear magnetic resonance. (3-0) Y

MSEN 6324 (EE 6324) Electronic Materials (*3 semester hours*) Principles of selection, preparation, and characterization of electronic materials with emphasis on semiconductors. Fundamentals of crystallography and crystal growth. Defect and impurity control. Thermodynamics and phase equilibria as applied to semiconductor processing. Preparation and properties of epitaxial and heteroepitaxial structures. Advanced techniques for structural, chemical and electrical characterization of electronic materials. Prerequisite: EE 6320 or equivalent. (3-0) T

ADVANCED COURSE LIST

MSEN 5340 Advanced Polymer Science and Engineering (*3 semester hours*) Polymer structure-property relations, Linear and nonlinear viscoelasticity. Dynamic mechanical analysis, time-temperature superposition, creep and stress relaxation. Mechanical models for prediction of polymer deformation, rubber elasticity, environmental effects on polymer deformation, instrumentation for prediction of long term properties. (3-0) R.

MSEN 5370 Ceramics and Metals (*3 semester hours*) Emphasis on structure-property relationships: chemical bonding, crystal structures, crystal chemistry, electrical properties, thermal behavior, defect chemistry. Chemical and physical properties of metals and alloys. Topics include: powder preparation, sol-gel synthesis, densification,

toughening mechanisms, crystal structure, thermodynamics, phase diagrams, phase transformations, oxidation, mechanical, electrical and magnetic properties. (3-0) R

MSEN 6310 Mechanical Properties of Materials (*3 semester hours*) Stress, strain and the basics of concepts in deformation and fracture for metals, polymers and ceramics. Analysis of important mechanical properties such as plastic flow, creep, fatigue, fracture toughness and rupture. Application of these principles to the design of improved materials and engineering structures. (3-0) Y.

MSEN 6330 Phase Transformations (*3 semester hours*) Thermodynamic, kinetic, and structural aspects of metallic and ceramic phase transformations: mechanisms and rate-determining factors in solid-phase reactions; diffusion processes, nucleation theory, precipitations from solid solution, order-disorder phenomena, and applications of binary and ternary phase diagrams. (3-0) R

MSEN 6350 Imperfections in Solids (*3 semester hours*) Point defects in semiconductors, metals, ceramics, and nonideal defect structures; nonequilibrium conditions produced by irradiation or quenching; effects of defects on electrical and physical properties, effects of defects at interfaces between differing materials. (3-0) R

MSEN 6377 (PHYS 6377) Physics of Nanostructures: Carbon Nanotubes, Fullerenes, Quantum Wells, Dots and Wires (*3 semester hours*) Electronic bands in low dimensions. 0-d systems: fullerenes and quantum dots. Optical properties, superconductivity and ferromagnetism of fullerides. 1-d systems: nano-wires and carbon nanotubes (CNTs). Energy bands of CNTs: chirality and electronic spectrum. Metallic versus semiconducting CNT: arm-chair, zigzag and chiral tubes. Electrical conductivity and superconductivity of CNTs, thermopower. Electromechanics of SWCNT: artificial muscles. Quantum wells, FETs and organic superlattices: confinement of electrons and excitons. Integer and fractional quantum Hall effect (QHE). (3-0) R

SPECIALIZED COURSE LIST

BIOL 5410 Biochemistry of Proteins and Nucleic Acids *(4 semester hours)* Chemistry and metabolism of amino acids and nucleotides; biosynthesis of nucleic acids; analysis of the structure and function of proteins and nucleic acids and of their interactions including chromatin structure. Prerequisite: biochemistry or equivalent. (4-0) Y

BIOL 5440 Cell Biology *(4 semester hours)* Molecular architecture and function of cells and subcellular organelles; structure and function of membranes; hormone and neurotransmitter action; growth regulation and oncogenes; immune response; eukaryotic gene expression. Prerequisites: BIOL 5410 and BIOL 5420, or the equivalent, or permission of the instructor. (4-0) Y

BIOL 6358 Bionanotechnology * *(3 semester hours)* Protein, nucleic acid and lipid structures. Macromolecules as structural and functional units of the intact cell. Parallels between biology and nanotechnology. Applications of nanotechnology to biological systems. (Note: taught as a special topics course in Fall 2004 with 8 enrolled.)

MSEN 5300 (PHYS 5376) Introduction to Materials Science (*3 semester hours*) This course provides an intensive overview of materials science and engineering and includes the foundations required for further graduate study in the field. Topics include atomic structure, crystalline solids, defects, failure mechanisms, phase diagrams and transformations, metal alloys, ceramics, polymers as well as their thermal, electrical, magnetic and optical properties. (3-0) R.

MSEN 5331 (CHEM 5331) Advanced Organic Chemistry I (*3 semester hours*) Modern concepts of bonding and structure in covalent compounds. Static and dynamic stereochemistry and methods for study. Relationships between structure and reactivity. (3-0) Y

MSEN 5333 (CHEM 5333) Advanced Organic Chemistry II *(3 semester hours)* Application of the principles introduced in CHEM 5331, emphasizing their use in correlating the large body of synthetic/preparative organic chemistry. Prerequisite: MSEN 5331/CHEM 5331. (3-0) R

MSEN 5341 (CHEM 5341) Advanced Inorganic Chemistry (3 semester hours) Physical inorganic chemistry addressing topics in structure and bonding, symmetry, acids and bases, coordination chemistry and spectroscopy. Prerequisite: CHEM 3341, or consent of instructor. (3-0) Y.

MSEN 5344 Thermal Analysis *(3 semester hours)* Differential scanning calorimetry; thermogravimetric analysis; dynamic mechanical and thermomechanical analysis; glass transition; melting transitions, relaxations in the glassy state, liquid crystalline phase changes. (3-0) S

MSEN 5353 Integrated Circuit Packaging (*3 semester hours*) Basic packaging concepts, materials, fabrication, testing, and reliability, as well as the basics of electrical, thermal, and mechanical considerations as required for the design and manufacturing of microelectronics packaging. Current requirements and future trends will be presented. General review of analytical techniques used in the evaluation and failure analysis of microelectronic packages. (3-0) R

MSEN 5355 (CHEM 5355) Analytical Techniques I (*3 semester hours*) Study of fundamental analytical techniques, including optical spectroscopic techniques and energetic particle and x-ray methods including SEM, EDS, STM, AFM, AES, XPS, XRF, and SIMS. (3-0) Y

MSEN 5356 (CHEM 5356) Analytical Techniques II (*3 semester hours*) Study of statistical methods (standard tests, statistical process control, ANOVA, experimental

design, etc.) and problem solving techniques for dealing with ill-defined analytical problems. (3-0) Y

MSEN 5361 Fundamentals of Surface and Thin Film Analysis (*3 semester hours*) Survey of materials characterization techniques; optical microscopy; Rutherford backscattering; secondary ion mass spectroscopy; ion channeling; scanning tunneling and transmission microscopy; x-ray spectroscopy; surface properties. (3-0) R

MSEN 5371 (PHYS 5371) Solid State Physics *(3 semester hours)* Symmetry description of crystals, bonding, properties of metals, electronic band theory, thermal properties, lattice vibration, elementary properties of semiconductors. Prerequisites: PHYS 5400 and 5421 or equivalent. (3-0) Y

MSEN 5375 (PHYS 5375) Electronic Devices Based On Organic Solids (*3 semester hours*) Solid state device physics based on organic condensed matter structures, including: OLEDs (organic light emitting diodes), organic FETs, organic lasers, plastic photocells, molecular electronic chips. (3-0) R

MSEN 5383 (PHYS 5383 and EE 5383) Plasma Technology (*3 semester hours*) Hardware oriented study of useful laboratory plasmas. Topics will include vacuum technology, gas kinetic theory, basic plasma theory and an introduction to the uses of plasmas in various industries. (3-0) Y

MSEN 6313 (EE 6313) Semiconductor Opto-Electronic Devices (*3 semester hours*) Physical principles of semiconductor optoelectronic devices: optical properties of semiconductors, optical gain and absorption, wave guiding, laser oscillation in semiconductors; LEDs, physics of detectors, applications. (3-0) T

MSEN 6320 (EE 6320) Fundamentals of Semiconductor Devices (*3 semester hours*) Semiconductor material properties, equilibrium carrier distribution and non-equilibrium current-transport processes; properties of semiconductor interfaces, including MOS, Schottky-barrier and p-n junctions. Prerequisite: EE 3310 or equivalent. (3-0) Y

MSEN 6321 (EE 6321) Active Semiconductor Devices (*3 semester hours*) The physics of operation of active devices will be examined, including bipolar junction transistors and field-effect transistors: MOSFETs, JFETS, and MESFETS. Special-purpose MOS devices including memories and imagers will be presented. Prerequisite: MSEN 6324. (3-0) Y

MSEN 6322 (EE 6322) Semiconductor Processing Technology (*3 semester hours*) Modern techniques for the manufacture of semiconductor devices and circuits. Techniques for both silicon and compound semiconductor processing are studied as well as an introduction to the design of experiments. Topics include: wafer growth, oxidation, diffusion, ion implantation, lithography, etch and deposition. (3-0) T

MSEN 6340 Advanced Electron Microscopy (*3 semester hours*) Theory and applications of scanning and transmission electron microscopy; sample preparation and analytical techniques. (3-0) Y

MSEN 6341 Advanced Electron Microscopy Laboratory (*3 semester hours*) Lab support for MSEN 6340. (0-3) Y

MSEN 6361 Deformation Mechanisms in Solid Materials** (*3 semester hours*) Linear elastic fracture mechanics, elastic-plastic fracture mechanics, time dependent failure, creep and fatigue, experimental analysis of fracture, fracture and failure of metals, ceramics, polymers and composites Failure analysis related to material, product design, manufacturing and product application. (3-0) S

MSEN 6362 Diffraction Science (*3 semester hours*) Diffraction theory; scattering and diffraction experiments; kinematic theory; dynamical theory; x-ray topography; crystal structure analysis; disordered crystals; quasi-crystals. (3-0) S

MSEN 6371 (PHYS 6371) Advanced Solid State Physics *(3 semester hours)* Continuation of MSEN 5371/PHYS 5371, transport properties of semiconductors, ferroelectricity and structural phase transitions, magnetism, superconductivity, quantum devices, surfaces. Prerequisite: MSEN 5371/PHYS 5371 or equivalent. (3-0) R

MSEN 6374 (PHYS 6374) Optical Properties of Solids (*3 semester hours*) Optical response in solids and its applications. Lorentz, Drude and quantum mechanical models for dielectric response function. Kramers-Kronig transformation and sum rules considered. Basic properties related to band structure effects, excitons and other excitations. Experimental techniques including reflectance, absorption, modulated reflectance, Raman scattering. Prerequisite: MSEN 5371/PHYS 5371 or equivalent. (3-0) T

MSEN 7320 (EE 7320) Advanced Semiconductor Device Theory (*3 semester hours*) Quantum mechanical description of fundamental semiconductor devices; carrier transport on the submicron scale; heterostructure devices; quantum-effect devices. Prerequisite: MSEN 6324. (3-0) R

MSEN 7382 (EE 7382) Introduction to MEMS (*3 semester hours*) Study of fabrication techniques for micro-electro-mechanical and micro-opto-mechanical devices and systems and their applications. Techniques for both silicon, non-silicon processing and emerging new micromachining processes are studied as well as their process physics. Topics to include: bulk and surface micromachining, electroplating-based micromachining and micro devices packaging. (3-0) Y

MSEN 7V80 Special Topics in Materials Science and Engineering (1-6 semester hours) For letter grade credit only. (May be repeated to a maximum of 9 hours.) ([1-6]-0) S

MSEN 8V40 Individual Instruction in Materials Science and Engineering (1-6 semester hours) (May be repeated for credit.) For pass/fail credit only. ([1-6]-0) R

MSEN 8V70 Research In Materials Science and Engineering (3-9 semester hours) (May be repeated for credit.) For pass/fail credit only. ([3-9]-0) R

MSEN 8V98 Thesis (3-9 semester hours) (May be repeated for credit.) For pass/fail credit only. ([3-9]-0) S

MSEN 8V99 Dissertation (3-9 semester hours) (May be repeated for credit.) For pass/fail credit only. ([3-9]-0) S