SYLLABUS

Physical Metallurgy (14-635:632)

Textbooks

1. *Materials Science and Engineering: An Introduction*, Callister, W.D., 6th or 7th edition, John Wiley & Sons, New York, 1999 (ISBN 0-471-32013-7).
2. *The Science and Design of Engineering Materials*, Schaffer, J.P., A. Saxena, S.D. Antolovich, T.H. Sanders, Jr., and S.B. Warner, 2nd edition, WCB/McGraw-Hill, New York, 1999 (ISBN 0-256-24766-8).

Week **Subject**

1. Classification of metals, their abundances and prices. Materials usage in today's advanced engineered systems.
2. Crystal systems and structures of metals. Calculations of linear, planar and bulk densities, and atomic packing factors. Use of Miller indices to define points, directions and planes in crystal-lattice systems.
3. Plastic deformation by crystallographic shear: observations of slip, operative slip systems, and derivation of critical resolved shear stress.
4. Edge, screw, and mixed dislocations. Dislocation mobility, multiplication, dissociation, and interactions.
5. Grain boundaries, sub-boundaries, and twins. Vacancies and interstitials.
6. Phase diagrams and their use in manipulating microstructures, and control of physical and mechanical properties.
7. Stress-strain behavior: yield strength, tensile strength, ductility, and toughness. Relationship between engineering and true stress-strain behavior. Variability of materials properties, design and safety factors.

Mid-term examination

8. Strengthening mechanisms: strain hardening, solid solution hardening, dispersion hardening, and precipitation hardening.
9. Mechanisms of ductile and brittle fracture, recovery and recrystallization, fracture toughness, fatigue, and creep.
10. Conventional casting, directional solidification, and rapid solidification processing.
11. Production of metal powders by inert-gas atomization, centrifugal atomization, mechanical attrition, and vapor condensation.
12. Consolidation of metal powders by sintering and hot isostatic pressing, and forming by hot rolling, swaging, and extrusion.
13. Processing and properties of steels, titanium alloys, and nickel-base alloys, and their applications.
14. Corrosion and degradation of materials: mechanisms, forms of corrosion, and methods of prevention.

Final examination

COURSE OUTLINE

Physical Metallurgy (14-635:362)

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Description

Fundamentals of plastic deformation, heat treatments, and processing of metals and alloys, including theories of yielding, plastic deformation, brittle fracture, time- and temperature-dependent phenomena, fatigue, and corrosion. Structure-properties-processing relationships of engineering alloys, and their design and optimization for specific applications.

Objectives

This course introduces MSE students to the fundamentals relating composition, structure and processing of metals and alloys and their properties. Students will gain an understanding of how to select materials for specific applications, and how to modify their properties to satisfy a specific set of performance requirements, taking into consideration cost, durability, and potential environmental impact. Throughout the course, examples will be given of conventional and specialty alloys usage in today's construction, transportation, energy, and consumer products industries. Materials problems will be discussed to underline the importance of the cross-disciplinary effort needed to integrate materials and component design in today's advanced engineered systems, such as gas-turbine engines, nuclear reactors, space vehicles, and communications systems.

Format

The course is in an interactive lecture format. The first half of the course considers crystal systems, structures of metals, slip systems, Schmid's law, dislocation theory, low- and high-angle grain boundaries, twinning, point defects, mechanical properties, and phase diagrams. The second half of the second half of the course addresses issues related to the mechanical properties of materials, and how these are strongly affected by composition, structure and processing. The practical importance of the subject is underscored by numerous examples of materials optimization through control of composition, structure and processing, e.g. rapid solidification of metals, directional solidification of gas turbine blades, and fabrication of metal-matrix composites.

Enrollment

To enroll in this course, students must have completed their freshman calculus, chemistry and physics courses required by MSE. Students in other engineering departments may also take the course as an elective.

Assessment

Student performance is assessed primarily through midterm and final examinations, which give equal emphasis to fundamental and applied aspects of the subject. The final grade is based upon the results of both exams.