

MatSE 423: PHYSICAL MATERIALS

Course Designation: Formerly designated Metal 405; this is a required course in the Metal Science and Engineering, and an elective course for other options.

Catalog Description: An introduction to phase equilibria, phase transformations and microstructure development in materials.

Course Description: This course integrates four core components of materials science and engineering: thermodynamics, kinetics, interface crystallography, and dislocation theory. It is the key course bridging the fundamental alloy theory to practical materials processing. Phase equilibria, phase diagrams, phase transformations and heat treatments are addressed in great detail through nucleation, transformation kinetics, crystal interface and diffusion. Specific phase transformations such as spinodal decomposition, martensitic transformations, ordering, solidification, devitrification, recrystallization, continuous/discontinuous precipitation are discussed. Case studies on materials and processing design using the above fundamentals are employed in both lecture and homework.

Prerequisites: MatSE 430, MatSE 470

Textbook: Compendium by Paul Howell and Zi-Kui Liu at the Penn State Book Store.

Course Objectives:

1. Learn the fundamental science of phase equilibria, phase diagrams, phase transformations and microstructure development in materials systems.
2. Understand microstructures and how they arise from alloy chemistry and processing.
3. Design alloy chemistry and processing tailored to given microstructure requirements.

Topics Covered:

1. Materials of Engineering Importance: Crystal Structures, Approximate Costs, and Relative Abundances in the Earth, Densities
2. Phase Equilibria and Phase Diagrams
3. Diffusion in the Solid State
4. Crystal Interfaces
5. Solidification and Devitrification
6. Nucleation in the Solid State
7. Precipitate and Growth Rates
8. Various Solid State Phase Transformations

Class Schedule: 4 credit course offered annually meeting 4 times per week.

Course Outcomes:

1. Be able to effectively use phase diagrams to understand equilibrium microstructure evolution during simple materials processing.
2. Given photomicrograph, be able to describe how the microstructure developed, considering both thermodynamics and kinetics of phase transformations.
3. Given open-ended problems, be able to design processes to develop optimized solutions with thermodynamic and kinetic principles.

Assessment Tools:

1. 10 to 15 home assignments with 30% on design questions that have no unique answers and will be open-ended
2. 10 mini in-class quizzes
3. 2 mid-term exams
4. 1 final exam

Professional Component: The course topics address the scientific and engineering principles regarding interrelations between materials compositions, processing and structure. A substantial emphasis is placed on integrating student's background in crystal structure, thermodynamics, kinetics, phase equilibria, and phase transformations to the design of materials processing.

Prepared by: Zi-Kui Liu, February 2002