ENG ME 531 Phase Transformations

2008-2009 Catalog Data:
ENG ME 531 Phase Transformations Prereq: ENG ME 306; grad prereq: ENG ME 306 or graduate standing. Graduate-level introduction to phase transformations; solution thermodynamics; phase diagrams; kinetics of mass transport and chemical reactions; atomistic models of diffusion; nucleation and growth; spinodal decomposition; martensitic transformations; order-disorder reactions; point defects and their relation to transport kinetics. 4 cr.

Class/Lab Schedule: 4 lecture hours per week

Status in the Curriculum: Elective

Textbook(s) and/or Other Required Material: "Phase Transformations in Metals and Alloys", D. A. Porter and K. E. Easterling, Chapman & Hall, 1993.

Supplementary Reading:
"Introduction to Metallurgical Thermodynamics", G. R. Gaskell.
"Diffusion in Solids", P. G. Shewmon.
"Chemical Kinetics", K. J. Laidler.
"Introduction to Ceramics", W. D. Kingery, H. K. Bowen and D. R. Uhlman.

Coordinator: Soumendra Basu, Professor, Mechanical Engineering

Prerequisites by topic:
1. Basic thermodynamics
2. Differential equations
3. Atomic bonding
4. Crystal structure

Goals:
1. Graduate level understanding of kinetics and phase transformations in materials, aimed at graduate students involved in research in materials.
2. Expose undergraduate students who might be contemplating graduate research in the materials area to more advanced topics in materials science.

Course Learning Outcomes:
As an outcome of completing this course, students will:

i. Gain a graduate level understanding of the fundamental principles of phase transformations.
ii. Gain the ability to apply the above principles to engineering materials.
iii. Gain an understanding of the utility of materials in industry.

Course Learning Outcomes mapped on to Program Outcomes:

Program:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Course:	i				i						ii,iii	ii,iii	iii	
Emphasis:	5	1	1	1	4	1	1	1	1	3	3	3	1	1

Topics:

1) Solution thermodynamics:
    a. Ideal solution model; regular solution model; Gibbs Duhem equation.
2) Phase diagrams:
    a. Gibbs phase rule; binary phase diagrams; ternary phase diagrams.
3) Diffusion:
    a. Fick's laws; thin film solution; error function solution; Laplace transforms; interdiffusion; atomistics of diffusion.
4) Chemical kinetics:
    a. Thermodynamics of chemical reactions; kinetics of chemical reactions; adsorption.
5) Surfaces and interfaces :
    a. Surface energy and surface tension; curvature of surfaces; anisotropic surfaces; grain boundaries and interfaces.
6) Thermally activated growth:
    a. Grain growth; equilibrium at curved surfaces; particle coarsening.
7) Nucleation and growth: Homogeneous nucleation; heterogeneous nucleation; interface controlled growth; diffusion controlled growth; combined nucleation and growth.
8) Solidification:
    a. Sheil equation; limited diffusivity in liquid; convection in liquid; constitutional supercooling; rapid solidification.
9) Spinodal decomposition:
    a. Thermodynamics of spinodal decomposition; kinetics of spinodal decomposition; experimental observation of spinodal decomposition.
10) Order-disorder reactions: Experimental observation of order disorder reactions; thermodynamics of order disorder reactions; antiphase boundaries.
11) Martensitic transformations:
    a. Characteristics of martensitic transformations; bain transformation in the Fe-C system; nucleation of martensite; transformation matrix.
12) Point defects:
    a. Point defects in alloys; point defects in compounds; nonstoichiometric compounds; diffusivity and point defects; Brouwer diagrams; oxidation.

Contribution of Course to Meeting the Professional Component:
Engineering topics: 100%

Status of Continuous Improvement Review of this Course:
Prepared by: Soumendra Basu **Date:** March 22, 2009