UNIVERSITY OF ILLINOIS
Grainger College of Engineering
Department of Materials Science and Engineering

Fall 2022: **MSE 501**
Kinetic Processes in Materials

Instructor:	Pascal Bellon, 312D MSEB, 265-0284, bellon@illinois.edu
Lecture:	TuTh 9:30-10:50 am, MSEB 4101
Office Hours:	Pascal Bellon: by appointment
Websites:	https://canvas.illinois.edu/ ; www.piazza.com

Prerequisites: MSE 500 and preferably one undergraduate materials kinetics course

Recommended books:

Kinetics of materials, R. W. Balluffi, S. A. Allen, W. C. Carter, 620.11292B214k

Phase transformations in metals and alloys, D. A. Porter and K. E. Easterling, 669.94P833p

Atom movements: Diffusion and mass transport in solids, J. Philibert, 530.415 P536D:E

Kinetic Processes: Crystal Growth, Diffusion, and Phase Transitions in Materials, K. A. Jackson, 530.136J132k2010

Solidification, J. A Dantzig and M. Rappaz, 669.94 D236s

Course Objectives: For students to (i) learn fundamental concepts underpinning kinetics in hard materials; (ii) become familiar with standard treatments of phase and microstructure evolutions in near-equilibrium and far-from-equilibrium alloys; (iii) apply this knowledge to practical problems; (iv) practice critical reading of scientific literature; and (v) practice developing research ideas and writing proposal.

Course Outline:

I. Diffusion in Solids
- I.1. Phenomenological continuum description
- I.2. Atomic theory of diffusion
- I.3. Diffusion in crystalline alloys
- I.4 Diffusion in non-crystalline materials

II. Nucleation, growth, and coarsening:
- II.1 Precipitation in alloys
- II.2 Recrystallization and grain growth

III. Spinodal decomposition
- III.1 Cahn-Hilliard theory
- III.2 Spinodal decomposition in the bulk
- III.3 Spinodal decomposition at surfaces and extended defects

IV. Order-disorder phases transitions
- IV.1 Continuous and discontinuous order-disorder transitions
- IV.2 Ordering kinetics: Allen-Cahn model

V. Solidification
- V.1 Balance equations and scaling
- V.2 Dendritic growth
- V.3 Eutectics
- V.4 Microstructure transitions

VI. Materials subjected to irradiation
- VI.1 Point defect production and evolution
- VI.2 Radiation-induced segregation and precipitation
- VI.3 Self-organization in dissipative systems

VII. Materials subjected to plastic deformation
- VII.1 Superdiffusive mixing by plastic deformation
- VII.2 Nonequilibrium microstructures and phases stabilized by severe plastic deformation

Grading: 33% Homework assignments: Keep 5 best scores
33% Selected literature review: 2 short in-class oral presentations
33% Individual term paper: On topic of your choice

GRADING POLICIES

You are expected to have read the Student Code section related to Academic Integrity (http://admin.illinois.edu/policy/code/article1_part4_1-401.html). All infractions listed in the Student Code, including cheating and plagiarism, will result in penalties in accordance with the Student Code. If you have any question regarding what constitutes an infraction, contact me.

HOMEWORK ASSIGNMENTS

There will be 6 homework assignments throughout the semester (roughly one every two weeks). You will complete these assignments through the Canvas website. Your overall assignment grade will be the average of your 5 best scores.

LITERATURE REVIEW

During the semester, each student will give in class two short critical reviews of one paper each, selected from an extensive list provided at the beginning of the semester.

TERM PAPER

Term paper topics will be defined by students, with review and approval from the instructor. Term papers will be short research proposals, written in the style of NSF proposals, i.e., they will include a review of relevant literature, the identification of knowledge gaps, the formulation of a research hypothesis, and proposed research.