MASC 504: Diffusion and Phase Equilibria
Spring 2017

Lectures: Monday and Wednesday 2:00 – 3:15 PM, OHE 122

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Objectives: The objective of the course is to introduce the science and applications of thermodynamics and kinetics in materials systems. Specifically, we will address the relevance of thermodynamics and kinetics for the synthesis, physical properties and phase evolution in these systems. The content will cover a range of materials systems with the primary focus on metals, alloys, ceramics, and covalent semiconductors. Special topics on polymers, quasi-crystalline, and metastable phases will also be included.

Books: Lecture slides will be provided and will contain all the information and necessary references to learn the material. In some cases, lecture notes and excerpts from textbooks will be supplemented. Significant material will be covered from these two textbooks.

1. Phase Transformations in Metals and Alloys by David Porter and Kenneth Easterling. ISBN: 9781420062106
2. Diffusion in Solids: Fundamentals, Methods, Materials, Diffusion-controlled Processes by Helmut Mehrer. ISBN: 9783540714866.

The following books are recommended for advanced reading.

Recommended list of books:

1. Kinetic Processes: Crystal Growth, Diffusion and Phase Transitions in Materials by Kenneth Jackson. ISBN: 9783527327362
2. Phase Transitions in Materials by Brent Fultz. ISBN: 9781107067240.
3. Phase Diagrams and Heterogeneous Equilibria by Bruno Predel, Michael Hoch and Monte Pool. ISBN: 9783662092767
4. Diffusion in Condensed Matter: Materials, Methods, Models by Paul Heitjans and Jorg Karger. ISBN: 9783540720812

Course website:

We will use the Desire2learn website for all the students enrolled in the class (on campus and DEN). The link to the site is: https://courses.uscden.net/d2l/login. If you have any

trouble registering and accessing the website, please contact the DEN@Viterbi technical support at dentsc@usc.edu or 213-740-9356.

Grading:

Exams (2):	30% each	=	60%
Problem Sets (6) and Class participation		=	30%
Final Term Paper		=	10%

Topics covered:

1) Introduction:

Kinetics and thermodynamics; Basics of Phase Transitions and Transformations.

2) Phase diagrams:

Theory of phase transitions; classifications; single component phase diagram, binary and ternary Phase diagram.

3) Diffusion:

Continuum theory of diffusion; defects and mechanisms of diffusion; mass diffusion in different materials systems (metals, alloys, semiconductors, ionic crystals and amorphous materials); beyond mass diffusion; applications of diffusion.

4) Crystals and Interfaces:

Coherent and incoherent interfaces; Grain boundaries; Domain boundaries.

5) Phase Transformations:

Nucleation and Growth; Diffusional and Diffusion-less transformation; Precipitation; Bulk processing of materials and low dimensional materials processing.

5) Meta-stability and advanced topics:

Amorphous Materials; Non-equilibrium materials processing.

Problem sets and Exam policy:

There will be one problem set made available every two weeks. The solutions to the problems will be due two weeks after the homework is posted. Each problem set will have 2-3 questions. Typically, these questions will have multiple parts, and will derive questions from the two weeks of lecture. The first problem set will be posted after the first week, and will comprise of the material taught in the first two weeks, and will be due on the 3rd week and so on. The scores will be made available typically within 2 weeks of submitting the problem sets and exams. The exams will be held for 1.5 hours each and will have 4-5 problems. More information about the exams will be provided in the class.

Modeling/Simulation:

The course will have small simple modeling exercises, typically in the form of simple programs using Matlab or Mathematica. These exercises will be aimed at helping you visualize diffusion profiles *etc.* and so, they are not expected to be extensive

programming exercises. If you have trouble using either of these softwares, and prefer to use a different one, please get in touch with the instructor at the beginning of the class.

Final Term Paper policy:

The final term paper will be used as a method to evaluate the student's final summative performance. The students are expected to write a brief review of a selected topic in this term paper. For example, topics relevant to phase transition, and/or diffusion in novel materials. You are also expected to typeset this article in a scientific journal format (*e.g.* Nature, Science, Advanced Materials, Physical Review Letters *etc.*) and mention the journal name in the review. You are expected to write this article in under 5 pages. Use any suitable schematics derived from any source (with suitable citations). This final term paper will be due during the finals week. The breakdown for the evaluation for the term paper is as follows:

Selection of topic, and its relevance to the course	– 10%
Formatting per the journal guidelines	– 20%
Content of the review	– 60%
Figures and Caption	– 10%
References	– 10%

Tentative Timeline:

Jan 9 – First class
Jan 16 – No class (Holiday)
Jan 18 – No class (Travel)
Jan 23 – HW 1 posted
Feb 6 – HW 2 posted; HW1 due
Feb 8 – No class (Travel)
Feb 20 – No class (Holiday)
Feb 22 – HW 3 posted; HW2 due
Mar 6 – HW3 due
Mar 8 – 1st Exam (For syllabus covered till Mar 1st)
Mar 13 – No class (Spring break)
Mar 15 – No class (Spring break)
Mar 20 – HW4 posted
Mar 27 – No class (Travel)
Apr 3 – HW5 posted; HW4 due
April 12 – HW6 posted
April 19 – HW5 due
April 24 – HW6 due
April 26 – 2nd Exam (For syllabus covered between Mar 9 - Apr 25)
May 5 – Final Paper due

<u>Statement on Academic Integrity</u>

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the

expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct.

http://www.usc.edu/dept/publications/SCAMPUS/gov/

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at:

http://www.usc.edu/student-affairs/SJACS/

Sanctions include but are not limited to: grade sanctions (e.g., "F" in course) and dismissal from the academic department (see following excerpt from SJACS site).

http://www.usc.edu/student-affairs/SJACS/forms/sjacs_appa.pdf

Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with the Office of Disability Services and Programs (DSP, STU 301, 213-740-0776) each semester. You must deliver an approved DSP letter to one of the instructors as early in the semester as possible. Please see SCampus (http://www.usc.edu/dept/publications/SCAMPUS/) for additional policies that are not covered here (i.e. academic integrity, proper conduct, etc) but that do still apply!