

Course: MTL5 3T04
Title: Phase Transformations

Instructor:

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Office Hours:

- Monday: 4:30 to 5:30 in **JHE 352**
- Thursday: 4:30 to 5:30 in **JHE 213C**

Teaching Assistants:

- Kezhuan Gu
- Maedeh Pourmajidian
- Reza Safari
- Aliyeh Rafiei

Calendar Description:

Molar Gibbs energy diagrams. Fundamentals of diffusion. Curved interfaces, Gibbs-Thomson effect. Grain growth, Zener pinning. Homogeneous and heterogeneous nucleation. Solidification. Scheil formalism. Constitutional supercooling. Eutectic growth. Coarsening. Recovery, recrystallization. Spinodal decomposition. Eutectoid, massive, order-disorder and martensitic transformations.

Three lectures, one lab (three hours); first term

Prerequisite(s): MATLS 1M03, 2D03 and 2X03.

Course Topics:

Week 1: Significance of phase transformations.

Week 2: Review of solution thermodynamics, regular solution model.

Week 3: Use of the common tangent construction, Gibbs Thomson Effect.

Week 4: Crystal interfaces, grain boundaries, grain-growth and recrystallization

Week 5: Diffusion control vs. interface control.

Week 7: Solidification.

Week 8: Diffusional transformations. Spinodal decomposition, homogenous and heterogeneous nucleation.

Week 9: Growth of precipitates. TTT and CCT diagrams. Age hardening.

Week 10: Pearlite and bainite transformations.

Week 11: Martensitic Transformation. Nucleation, growth. Martensite crystallography.

Week 12: Tempering of martensite.

Week 13: Review.

Course Objectives:

At the conclusion of this course, the student should be able to:

- a. Describe the Gibbs energy of mixing of binary alloys and relate it to the phase diagram.
- b. Describe the key features of diffusional and non-diffusional transformations.
- c. Describe the processes of homogenous and heterogeneous nucleation.
- d. Identify the boundary conditions that operate during a diffusional phase transformation.
- e. Understand the factors that control the kinetics of various phase transformations.
- f. Describe the role of phase transformations in microstructure development.
- g. Apply their knowledge of microstructure development to failure analysis problems.
- h. Work effectively in a team.
- i. Use modern engineering tools to characterize the microstructure of common engineering materials.

Professional Development:

MATLS 3T04 is an important part of your training as an engineer. In particular:

Items (a-f) will contribute to your specialized engineering knowledge (CEAB attribute 1.4). The failure analysis lab, item (g), will also contribute to attribute 2 (Problem Analysis) and attribute 3 (Investigation). This course will also give you exposure to modern engineering tools, item (i), which is linked to attribute 5 (Use of Engineering Tools). Finally, the team work component of this course, item (h), will contribute to developing your ability to work individually and in teams (attribute 6).

Primary Textbook:

D. Porter, K. Easterling and M. Sherif, Phase Transformations in Metals and Alloys, 3th edition, CRC Press.

Other useful Resources:

- Hoyt, Phase Transformations
- Shewmon, Phase Transformations in Metals
- Haasen, Physical Metallurgy
- Veerhoeven, Fundamentals of Physical Metallurgy
- Kingery, Introduction to Ceramics

Lectures:

Monday, Wednesday and Thursday at 5:30, JHE 326H.

Laboratories:

Laboratories are scheduled every week. Each student will perform five experiments each spanning two weeks. The experiments are listed below and described in detail in the laboratory manual:

- (A) Solidification and Casting
- (B) Nucleation and Growth of Crystals in Amorphous Polymers
- (C) Phase Transformations and Age-hardening in Non-Ferrous Alloys.
- (D) Pearlite Transformation
- (F) Failure Analysis

Evaluation:

Lab Participation (A,B,C,D,F):	10%
Failure Analysis Lab (F)	10% (5% for the report and 5% for the presentation).
Quizzes (3):	45% 1 hour each, weeks of Sept. 26 th , Oct. 31 th , Nov. 21 st
Final Exam	35% 2 hr exam.

* For labs A, B, C and D the student will receive 2% for attending the lab, performing the required tasks and participating in the lab discussion with the TA. All students are expected to keep a hard bound lab book in which all lab observations and discussions are recorded. The TA will initial these at the end of each lab.

* The failure analysis lab requires a formal lab report. The report is due on December 7th. The failure analysis presentations will take during lab time on Nov. 29 and Dec. 1, 2016. Lab reports should be scanned and submitted into the appropriate drop-off box on Avenue. Late lab reports will be penalized 25% per day.

Policy Reminders:

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons involved, individual are reminded that they should contact the Department Chair, the Sexual Harassment Office or the Human Rights Consultant, as soon as possible.

The Senate Resolution on Course Outlines states that:

“students should be reminded that they should read and comply with the "Statement on Academic Ethics and the Senate Resolution on Academic Dishonesty" as found in the Senate Policy Statements distributed at registration and available in the Senate Office”.

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at: http://www.mcmaster.ca/senate/academic/ac_integrity.htm

The following illustrates only three forms of academic dishonesty:

- Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- Improper collaboration in group work.
- Copying or using unauthorized aids in tests and examinations.

Accessibility:

McMaster University is committed to fostering, creating and maintaining a barrier-free environment for all individuals providing equal rights and opportunities, including:

- Promoting a respectful attitude for persons with disabilities;
- Promoting awareness of the needs and abilities of persons with disabilities;
- Informing the University community about the services available to persons with disabilities and seeking to ensure that such services are delivered in ways that promote equity; and
- Providing support services, subject to certain limitations.

Students requiring service or accommodation contact Student Accessibility Services (SAS): <http://sas.mcmaster.ca/> as soon as possible.

For more information, please visit <http://mcmaster.ca/policy/Students-AcademicStudies/>

Disclaimer:

"The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes."

Completed by: Hatem S. Zurob, September 2016