Course Syllabus
Micro and nanostructures in materials
MH2017

Main content
The course covers

- equilibria and transformations in metallic materials
- fundamental theory of phase transformations
- fundamental thermodynamics and application of binary phase diagrams
- formation of micro- and nanostructures through nucleation and growth
- crystalline and amorphous solidification
- transformations in solid phases
- recrystallization, grain growth and coarsening
- TTT- and CCT diagram
- calculate the effect of surface energy on equilibrium, driving force for initial precipittion, critical radius for nucleation, growth rates, segregation during solidification, grain growth, transformation rate

Learning outcomes
After passed course, the student should know how to:

1. describe basic terminology and concepts of metallic materials microstructure and transformations.
2. identify characteristic structural elements and analyze a microstructure of a material and draw conclusions on how the material has been processed and what phase transformations have taken place using phase diagrams.
3. describe the most common transformations and structures in the most commonly used metallic materials and analyze how they are affected by various factors, e.g. composition and temperature, as well as explain and motivate which basic chemical and physical quantities, such as e.g. surface energy and diffusion, are of importance.
4. perform calculations regarding microstructure development under reasonable assumptions.
5. explain and schematically show the geometric meaning of concepts central to phase transformations in a Gibbs energy diagram and its connection to phase diagrams.
6. apply TTT and CCT diagrams to analyze what happens in a material under certain conditions.

Grading criteria
Fx: the student fulfills all learning outcomes 1-6 except one. This learning outcome is examined through an extra assignment.
E: the student meets the learning outcomes 1-6 at the basic level
D: requirements for E and D in one of learning outcomes 1-4
C: requirements for E and C in two of learning outcomes 1-4
B: requirements for E and B in three of learning outcomes 1-4
A: requirements for E and A in three of learning outcomes 1-4

Goal completion

- Attendance and approved tests in all laboratory sessions
- All home assignments are approved
- All learning outcomes are met to level E which is tested in

Learning outcome	E	D-A
1	Lab/exam	exam
2	HA/lab/exam	exam
3	HA/exam	exam
4	HA/exam	exam
5	HA	
6	Lab	

and higher grading is tested in the written exam.

Contact

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Canvas

Home assignments, solutions to the exercises, etc. will be posted in the modules on Canvas.

Activities and examination

Videos:
All videos will be published on Canvas:

1: Gibbs - Thomson's equation
2: Driving force
3: Nucleation
4: Growth
5: Kinetics/KJMA
6: TTT and CCT diagrams
7: Precipitation hardening
8: Solidification
9: Segregation
10: Recrystallisation
11: Grain growth
12: Coarsening
13: Allotropic modifications
14: Martensitic transformation
15: Phase transformations in steel
16: Cast iron

Lectures:
To prepare to the lectures please see the videos on the topics for the lecture, read the related chapters in the book and solve the exercises specified for each lecture.

On lectures 2-7 I will give a very short summary of the videos published on Canvas including some mentimeter questions, but also solve some exercises and answer any questions.

Lecture 1:	Introduction, repetition Reading: Chap 1.1-1.2
Lecture 2:	Gibbs-Thomsons equation, driving force, nucleation Exercises: 1:2, 1:3, 1:4, 2:1, 2:2 and 2.3 Reading: Chap 1.3-1.4, 1.6, 2.1-2.2 2.4-2.5, skim through 2.3
Lecture 3:	Growth, morphological stability Exercises: 3:3 and 3:4 Reading: Chap 1.5 and 3
Lecture 4:	Kinetics, TTT- and CCT-diagrams, precipitation hardening Exercises: 6:1, 6:2, 6:3 and 2:4 Reading: Chap 6, 11.4
Lecture 5:	Solidification, segregation, recrystallisation, grain growth and coarsening Exercises: 4:3, 4:6, 5:1, 5:2 and 5:3 Reading: Chap 4.1-4.3, 4.5-4.7, 5, skim through 4.4, 4.8-4.9
Lecture 6:	Allotropic modifications, martensitic transformation Exercises: 10:1, 11:2 and 11:3 Reading: Chap 7.1-7.3, 9.3, 9.1 and 10.6-10.7
Lecture 7:	Phase transformations in steel, cast iron Exercises: Met:9 and Met:13 Reading: Chap 9.2, 11.2.1, 7.4, 9.4 Old exam

Exercises:
On the exercises, the MET exercises will be solved.

Home assignments, 1 hp:
There are 3 compulsory home assignments. The home assignments may be solved in groups of 2. Identical or nearly identical solutions from different groups will not be accepted.

Labs, 1 hp:
The labs are compulsory and are 3 h long. The labs are in the blue lecture room. Each labs start with a test. Information on how to prepare is posted on Canvas.

Lab 1:	Repetition and identification of unknown materials
Lab 2:	Transformations during isothermal heat treatment and continuous cooling
Lab 3:	Cast Iron + Stainless steel
Lab 4:	Martensite + Aluminum bronze

Written examination, 4 hp:
The examination tests that learning outcomes 1-4 are met to level E. The result of the exam determines the grading. The exam consists of two parts. On the first part only calculator and the collection of phase diagrams are allowed and on the second part, all course literature is allowed. The maximum number of points is 100. The written examination will be available in both Swedish and English.

The own examination is possible to check at the students office. The assessment of an individual examination exercise may be appealed in written to Annika Borgenstam within 1 month from the date the examination result was posted.

Course literature:

- M Hillert, J Ågren and A Borgenstam, Micro and nanostructures in materials design

- Metallographic atlas
- Collection of phase diagrams

The course literature is available on Canvas and at Kårbokhandeln.

The metallographic atlas is also available at www.met.kth.se/ia/index.html
User name: MAVE-00
Password: rot