

# Course Syllabus

## Micro and nanostructures in materials

### MH2017, MH2038

#### 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 precipitation, 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

*Teacher and Coordinator:*

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*Lab assistants:*

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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:

Lecture 1 will be given in M2 and lectures 2-10 will be given on Zoom. 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 2-9 I will give a very short summary of the videos published on Canvas including some mentimeter questions, answer any questions. Home assignments solutions will also be discussed.

The same Zoom-link will be used on all lectures: <https://kth-se.zoom.us/j/67131826808>

- Lecture 1: Introduction, repetition  
Reading: Chap 1.1-1.2
- Lecture 2 (Zoom): Gibbs-Thomsons equation, driving force  
Exercises: 1:2, 1:3 and 1:4  
Reading: Chap 1.3-1.4
- Lecture 3 (Zoom): Nucleation  
Exercises: 2:1, 2:2 and 2.3  
Review HA 1  
Reading: Chap 1.6, 2.1-2.2 2.4-2.5, skim through 2.3
- Lecture 4 (Zoom): Growth, morphological stability  
Exercises: 3:3 and 3:4  
Reading: Chap 1.5 and 3
- Lecture 5 (Zoom): Kinetics, TTT- and CCT-diagrams, precipitation hardening  
Exercises: 6:1, 6:2, 6:3 and 2:4  
Reading: Chap 6, 11.4
- Lecture 6 (Zoom): Solidification, segregation  
Exercises: 4:3 and 4:6  
Review HA 2  
Reading: Chap 4.1-4.3, 4.5-4.7, skim through 4.4, 4.8-4.9
- Lecture 7 (Zoom): Recrystallisation, grain growth and coarsening  
Exercises: 5:1, 5:2 and 5:3  
Reading: Chap 5
- Lecture 8 (Zoom): 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 9 (Zoom): Phase transformations in steel, cast iron  
Exercises: Met:9 and Met:13  
Review HA 3  
Reading: Chap 9.2, 11.2.1, 7.4, 9.4
- Lecture 10 (Zoom): Repetition

**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.

Dates for submission of home assignments in Canvas:

HA 1: Sep 3rd  
HA 2: Sep 17th  
HA 3: Oct 1st

**Labs, 1 hp:**

The labs are compulsory and are 3 h long. The labs are in the blue lecture room. Each lab starts 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](http://www.met.kth.se/ia/index.html)

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