Functional Inorganic Materials

CHEM-E4215 (5 cr)

Lectures (12 x): Tuesday 10.15 – 12.00
Thursday 10.15 – 12.00

Remote lectures
(*see MyCourses for link*)

Lecturers: Maarit Karppinen
Antti Karttunen
Mady Elbahri

- **Lectures: 12 x 2 h**
- **Home problem solving 40 h**
- **Independent homework 71 h**

MARKING (max 100 points)

- **Lecture Exercises 36 points**: 12 x 3 p (min. 18 p)
- **Learning Diary 64 points**: 12 x 5 p + 4 p (min. 32 p)
- **NO EXAM (this year) !**

After the course the student:

1. has an overview of the variety of inorganic materials employed in advanced technologies
2. is able to discuss the most important physical properties of functional inorganic materials
3. is able to analyze the "basic chemistry" – "crystal structure" – "microstructure" – "physical property" relations in functional materials
4. is able to read and critically evaluate scientific papers on topics related to inorganic materials chemistry

The course provides/covers/focuses:

- insights into various important/new functional inorganic material families
- applications related to e.g. new sustainable energy technologies, conventional electronics, optics, spintronics & other emerging fields
- e.g. superconductive, magnetic, ferroelectric, thermoelectric, Li-ion and oxide-ion conductive & photoactive materials
- physical phenomena behind the targeted material functions

Functional Inorganic Materials
Fall 2020

Tuesdays: 10.15 - 12.00
Thursdays: 10.15 - 12.00
Remote Zoom lectures

#	Date	Who	Topic
1	Tue 27.10.	Maarit	Introduction + Superconductivity: High-T_c superconducting Cu oxides
2	Thu 29.10.	Maarit	Ionic conductivity (Oxygen): Oxygen storage and SOFC
3	Tue 03.11.	Maarit	Ionic conductivity (Lithium): Li-ion battery
4	Thu 05.11.	Maarit	Hybrid materials
5	Tue 10.11.	Antti	Thermal conductivity
6	Thu 12.11.	Antti	Thermoelectricity
7	Tue 17.11.	Antti	Ferro-, pyro-, and piezoelectricity
8	Thu 19.11.	Antti	Magnetic and multiferroic oxides
9	Tue 24.11.	Mady	Metal-based energy-saving applications
10	Thu 26.11.	Mady	Metal-based energy-efficient windows and solar absorbers
11	Tue 01.12.	Mady	Metal oxides for energy-saving applications: Past and new trends
12	Thu 03.12.	Mady	Materials design and new perspectives

Lecture Exercises

- **You will get the exercise questions and also the detailed instructions before or during each lecture**
- **The question/assignment style may somewhat differ depending on the lecture subject and/or lecturer**
- **Here are the instructions for the first four exercises (by Maarit)**
  - You will receive the question set simultaneously with the lecture notes in MyCourses before each lecture
  - You should return your answers as a pdf-file in MyCourses
  - Deadline for the return of the answer file is always two days later by midnight
  - Answering to the questions may require some self-learning/homework (e.g. literature search/reading)
- **Important to remember:** you can earn more than one third of the score points with these lecture exercises !

Learning Diary

- **Purpose of the learning diary**
  - Deepen **your understanding** of the subject
  - Urge you to develop **your learning process**
  - Help the teachers to improve the course
- **Structure of diary (for each individual lecture)**
  - State clearly whether you attended or not the Zoom lecture
  - Short summary of the lecture topic
  - Summarize shortly what did you know about the topic beforehand
  - What was the **most important new knowledge/understanding** you gained from the lecture
  - Did something remain unclear / Did you try to clarify afterwards
  - What kind of **additional information related to the topic** you got inspired to find (particularly important when you: (i) aim at the highest grade, (ii) did not attend the lecture)
- **Practicalities**
  - The whole diary in a single file & return it weekly through MyCourses by “next-week” Monday
  - For each lecture 2-3 pages (some figures may be included); In total 20-30 pages
  - Write a last short summary chapter, where you reflect on the whole course (4 points):
    * Did your interest in the course subjects change during the course
    * Did your learning process change during the course
    * What grade would you give for yourself
- **Important to remember:** your learning diary is the major part of your course evaluation!

Typical framework of the lecture

- Phenomenon/Function & Applications (~20 min)
- Material requirements (e.g. chemistry & structure) (~20 min)
- Existing state-of-the-art materials (~30 min)
- Design of new materials (~30 min)

EXAMPLES OF FUNCTIONS/DEVICES

- High-T_c superconductors
- Thermoelectrics
- Optics
- Ferro, pyro & piezoelectrics
- Oxygen storage
- SOFCs
- Li-ion battery

RESEARCH GOALS

- Enhanced performance
- Better safety, cheaper price, environmental aspects
- Replacement of critical raw materials
- Discovery of new enabling materials

TYPES OF MATERIALS

- Metals and alloys
- Oxides and other ceramics
- Hybrids and composites

EXAMPLES OF IMPORTANT PHYSICAL PROPERTIES

- Electrical conductivity
- Ionic conductivity
- Thermal conductivity

CHEMICAL TOOLS FOR MATERIAL TAILORING

- Crystal structure (e.g. layered structure, high symmetry)
- Chemical substitutions: partial/complete; isovalent/aliovalent; chemical pressure/carrier doping
- Redox chemistry (e.g. oxygen content control)
- Nanostructuring
- Surface coating
- etc.