Functional Inorganic Materials

CHEM-E4215 (5 cr)

Lectures (12 x): Tuesday 12.15 – 14.00
Thursday 10.15 – 12.00

Three different lecture halls (for details, see see the next slide)

Lecturers: Maarit Karppinen
Antti Karttunen

- **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**

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 2022

Tuesdays: 12.15 - 14.00
Thursdays: 10.15 - 12.00

Lecture hall locations: U7 and U8 in Otakaari 1 / U-wing
Ke1 in Kemistintie 1 (CHEM building)

You can use https://usefulaaltomap.fi/ to see the exact location of U7 and U8.

#	Date	Place	Who	Topic
1	**Mon** 5.9. (12.15)	**U7 (U135a)**	Maarit	Introduction + Material design
2	Thu 8.9.	Ke1 (A305)	Antti	Introduction + Computational materials design
3	Tue 13.9.	U8 (U270)	Maarit	Superconductivity: High-T_c superconducting Cu oxides
4	Thu 15.9.	Ke1 (A305)	Maarit	Magnetic oxides
5	Tue 20.9.	U8 (U270)	Maarit	Ionic conductivity (Oxygen): Oxygen storage and SOFC
6	Thu 22.9.	Ke1 (A305)	Maarit	Ionic conductivity (Lithium): Li-ion battery
7	Tue 27.9.	U8 (U270)	Antti	Thermal conductivity
8	Thu 29.9.	Ke1 (A305)	Antti	Thermoelectricity
9	Tue 4.10.	U8 (U270)	Antti	Piezoelectricity
10	Thu 6.10.	Ke1 (A305)	Antti	Pyroelectricity and ferroelectricity
11	Tue 11.10.	U8 (U270)	Maarit	Hybrid materials
12	Thu 13.10.	Ke1 (A305)	Antti	Luminescent and optically active materials

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.

Lecture Exercises

- **You will get the exercise questions and also the detailed instructions before or during each lecture**
- **The questions/assignments may somewhat differ depending on the lecture subject and/or lecturer**
- **Important to remember:** you can earn more than one third of the course 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 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 in MyCourses
  - 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 most important part of your course evaluation!