Functional Inorganic Materials

CHEM-E4215 (5 cr)

Lectures (12 x): Tuesday 14.15 – 16.00
Thursday 12.15 – 14.00

Remote lectures
(*see MyCourses for link*)

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 2021

Tuesdays: 14.15 - 16.00
Thursdays: 12.15 - 14.00
Remote Zoom lectures

#	Date	Who	Topic
1	Tue 02.11.	Maarit	Introduction + Materials design
2	Thu 04.11.	Antti	Computational materials design
3	Tue 09.11.	Maarit	Superconductivity: High-T_c superconducting Cu oxides
4	Thu 11.11.	Maarit	Ionic conductivity (Oxygen): Oxygen storage and SOFC
5	Tue 16.11.	Maarit	Ionic conductivity (Lithium): Li-ion battery
6	Thu 18.11.	Antti	Thermal conductivity
7	Tue 23.11.	Antti	Thermoelectricity
8	Thu 25.11.	Maarit	Hybrid materials
9	Tue 30.11.	Maarit	Luminescence and optically active materials
10	Thu 02.12.	Antti	Piezoelectricity
11	Tue 07.12.	Antti	Pyroelectricity and ferroelectricity
12	Thu 09.12.	Antti	Magnetic and multiferroic oxides

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 MATERIAL FUNCTIONS / APPLICATIONS

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

RESEARCH TARGETS

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

TYPES OF MATERIALS

- 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

Lecture Exercises

- **You will get the exercise questions and also the specific instructions before or during each lecture**
- **The questions/assignments may somewhat differ depending on the lecture subject and/or lecturer**
- **Here are the instructions for the six 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
  - **Deadlines** for the return of the answer file are:
    Thursdays by 12.00 & Mondays by 16.00
- **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 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 ask during the lecture** / Did you 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
- **Your learning diary is the major part of your course evaluation!**