MSE-432

Introduction to magnetic materials in modern technologies

Grundler Dirk

Cursus	Sem.	Type
Materials Science and Engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Interactive course addressing bulk and thin-film magnetic materials that provide application-specific functionalities in different modern technologies such as e.g. wind energy harvesting, electric article surveillance, spintronics, sensing, and data storage.

Content

The course explains the relation between properties of magnetic materials and their composition, structure, as well as underlying preparation techniques.

1. Introduction to magnetic phenomena
2. Basic concepts of magnetic materials
3. Fabrication and synthesis techniques (bulk materials, thin films, nanoscale materials)
4. Electric, magnetic, mechanical, and optical properties depending on composition, structure, preparation technique
5. Figure-of-merits of magnetic materials in different technologies and performance tests
6. Applications (e.g. storage, electric article surveillance, sensors, spintronics)
7. Abundance of relevant elements, sustainability

Keywords

Spontaneous magnetism, magnetism of elements and alloys, invar, ferro-, ferri- and antiferromagnetic, saturation magnetization, magnetic anisotropies, stray field, demagnetization effect, reversible and irreversible reversal processes, hysteresis, domain walls, dc and ac magnetic susceptibility, exchange interaction, dipolar forces, Landau-Lifshitz-Gilbert equation and spin dynamics, nonreciprocity, magnetoelastic coupling, exchange bias, Delta-E effect, heat-assisted recording, hard and soft magnets, magnetoelectronics (spintronics)

Learning Prerequisites

Required courses

Electromagnetism (or General Physics III); a course about fundamentals of solid matter, e.g. Fundamentals of solid-state materials, Solid state physics, Theory of materials: from structures to properties, or equivalent

Important concepts to start the course

Electromagnetism (Maxwell equations), concepts of electronic configurations in atoms: atomic orbitals, electron spin, Hunds rule

Learning Outcomes

By the end of the course, the student must be able to:

- Categorize magnetic materials
- Optimize the resource-efficient usage of magnetic materials
- Apply micromagnetic simulations
- Choose an appropriate fabrication method
- Assess / Evaluate classical versus quantum mechanical aspects of magnetic technologies
- Decide on magnetic materials in low- and high-frequency applications
- Compare magnetic materials concerning costs and operation conditions
- Justify materials aspects for novel magnetic devices

Transversal skills

- Use a work methodology appropriate to the task.
- Communicate effectively, being understood, including across different languages and cultures.
- Use both general and domain specific IT resources and tools
- Collect data.
- Take feedback (critique) and respond in an appropriate manner.
- Respect the rules of the institution in which you are working.

Teaching methods

Ex cathedra, exercises, simulations, visit to laboratory, presentations of students

Expected student activities

Attendance at lectures and exercise classes, completing exercises (problem sets), feedback, performing simulations, report writing, presentations

Assessment methods

During the term:

- written solution to problem set 1 (10%)
- oral presentation including a short summary document (30 %)
- written report and presentation of simulation results (40 %)
- written solution to problem set 2 (20 %)

Supervision

Office hours	Yes
Assistants	Yes

Resources

Bibliography

Available at library, eg. B.D. Cullity, C.D. Graham, Introduction to Magnetic Materials, (2009); J.D. Coey, Magnetism and Magnetic Materials (2010). R.C. O'Handley, Modern magnetic materials: principles and applications (2000); the library provides several copies of the book by K. Krishnan (Fundamentals and Applications of Magnetic Materials)

Ressources en bibliothèque

- Introduction to Magnetic Materials / Cullity
- Fundamentals and Applications of Magnetic Materials / Krishnan
- Magnetism and Magnetic Materials / Coey

- Modern magnetic materials: principles and applications / O'Handley

Moodle Link

- https://go.epfl.ch/MSE-432

Prerequisite for

Semester projects, Master thesis, PhD