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, optical, and thermal 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, Ising model, Landau-Lifshitz-Gilbert equation and spin dynamics, magnetoelastic coupling, exchange bias, Delta-E effect, heat-assisted recording, hard and soft magnets, magnetoelectronics (spintronics), magneto-optics

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, Hund's 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, completing exercises, feedback via electronic means (e.g. clickers), performing simulations, report writing, presentation

Assessment methods
During the term (exercises, oral presentations, reports)

Supervision
Office hours Yes
Assistants Yes

Resources
Bibliography

Ressources en bibliothèque
• Introduction to Magnetic Materials / Cullity
• Modern magnetic materials: principles and applications / O’Handley
• Magnetism and Magnetic Materials / Coey
• Fundamentals and Applications of Magnetic Materials / Krishnan

Notes/Handbook
Please get a polling device (clicker) from the library (see link below) before the start of the lecture.

Websites
• http://clickers.epfl.ch/students

Moodle Link
• http://moodle.epfl.ch/course/view.php?id=15219

Prerequisite for
Semester projects, Master thesis, PhD