EPFL

MSE-496

Charge transport in energy conversion and storage

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Cursus	Sem.	Type
Materials Science and Engineering		Obl.
Materials Science and Engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Fundamental concepts of charge transport in solar cells, batteries, and electrolysers, emphasizing analogies between semiconductor physics and electrochemistry.

Content

The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolysers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in materials science, electrical engineering, physics, and chemistry.
By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

Keywords

Energy, energy transition, sustainable energy, renewable energy, energy conversion, energy storage, solar cells, batteries, electrolyser, materials science, semiconductor physics, electrochemistry

Learning Prerequisites

Required courses

Elements of calculus will be reviewed during the lectures, where necessary, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite.
Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students.

Teaching methods

This course is taught simultaneously at ETH Zurich and EPFL Lausanne. All lectures will be recorded by zoom and made available to the students. Lectures will be streamed live from ETH Zurich with four lectures taught onsite at EPFL Lausanne.
A visit to Empa's Energy Conversion and Storage Labs will be organized at the beginning of the semester. Possibility to interact and meet your classmates from ETH Zurich via online lecture platform and during two special lectures with guest lecturers from industry (one guest lecture by ABB at ETH Zurich, one guest lecture by Northvolt at EPFL). Travel expenses for students will be covered.

Expected student activities

Assessment methods

Written exam 90 min

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes
Others	Office hours Friday after each exercise session (onsite or online)

Resources

Bibliography

P. Würfel, Physics of Solar Cells: From Principles to New Concepts, DOI:10.1002/9783527618545
J. Newman, Electrochemical Systems, ISBN 978-1-119-51460-2
R. Huggins, Advanced Batteries, DOI:10.1007/9780387764245

Ressources en bibliothèque

- Würfel, P., Physics of Solar Cells: From Principles to New Concepts
- Newman, J., Electrochemical Systems,
- Huggins, R., Advanced Batteries

Moodle Link

- https://go.epfl.ch/MSE-496