CH-429

Energy conversion by semiconductor devices

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Cursus	Sem.	Type
Chimiste	MA1, MA3	Opt.

Language of teaching	English
Credits	2
Session	Winter
Semester	Fall
Exam	Oral
Workload	60h
Weeks	14
Hours	**2 weekly**
Courses	2 weekly
Number of positions	

Summary

This course aims to present an introduction to the fundamentals of semiconductor physics, photophysics,photoelectrochemistry,and the practical applications.

Content

Detailed Content :

1.
Fundamental physical chemistry of semiconductor materials
- Energy band diagrams
- Density of states and fermi-dirac distribution
- Metal-semiconductor junction and pn junction
- Inorganic semiconductor vs organic semiconductor - Low dimensional materials

2.
Light-semiconductor interactions
- Charge carrier generation and recombination in semiconductor - Equilibrium and non-equilibrium states
- Absorption and photoluminescence
- Nature of solar energy
- Thermodynamic limits of solar energy conversion

3. Applications
- Light emitting diodes: operation principle, material and devices
- Solar cells: operation principle, characterization methods and materials, solar cells including pn junction solar cells, organic photovoltaics, dye-sensitized solar cells, organic-inorganic hybrid perovskite solar cells
- Photoelectrochemistry: semiconductor-liquid junctions, basic electrochemistry, and operation principle, characterization methods and materials/devices
- Photocatalysts: operation principle, photocatalytic materials, characterization methods

Keywords

Photophysics, Photoelectrochemistry, Organic/Inorganic Semiconductors, Nano- materials, Light-matter interaction, Solar energy

Learning Prerequisites

Recommended courses

General physics: electromagnetism
Functional properties of materials (or equivalent)

Learning Outcomes

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

- Demonstrate knowledge of basic photophysics and photoelectrochemistry
- Demonstrate basic knowledge of semiconductor physical chemistry
- Describe the electronic and optical properties of idealized intrinsic semiconductors and extrinsic semiconductors
- Describe the physical properties developed at junctions formed by dissimilar materials
- Classify the differences between inorganic semiconductors and organic semiconductors
- Describe the carrier statistics under non-equilibrium compared to equilibrium
- Describe candidate semiconducting materials and their requirements for the optoelectronic devices
- Describe the photophysical and photoelectrochemical processes in semiconductors
- Describe operation principles of LEDs, solar cells, photodiodes, photoelectrochemical water splitting devices, and photocatalyst
- Discuss parameters to improve performance of optoelectronic devices
- Explain how to characterize the optoelectronic devices and the operation principles of the analytic tools, e.g. spectroscopic tools, electrochemical tools, photoelectrochemical tools.

Teaching methods

12 x 2h lectures with suggested exercises and 2 sessions at the end used for oral presentations.

Expected student activities

This course aims to present an introduction to photovoltaic and photoelectrochemical energy conversion to students with a background in materials/physical chemistry or chemical engineering. First the fundamentals of photophysics, photoelectrochemistry, and semiconductor physics are introduced. Then, the principles of photon-semiconductor interactions and photoelectrochemical properties of semiconductors and their formed junctions will be discussed. As practical applications, photovoltaics, light emitting diodes, photodiodes, and photoelectrochemical/photocatalytic water splitting devices will be described and their thermodynamic energy conversion limitations will be introduced. Methods to characterize and evaluate the optoelectronic properties of semiconductor materials will also be detailed.

Assessment methods

Oral presentation and oral examination

Resources

Moodle Link

- https://go.epfl.ch/CH-429