EPFL

ME-469

Nano-scale heat transfer

Tagliabue Giulia

Cursus	Sem.	Type
Mechanical engineering minor	E	Opt.
Mechanical engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	1 weekly
Project	1 weekly
Number of positions	

It is not allowed to withdraw from this subject after the registration deadline.

Summary

Micro/nano systems are at the core of numerous established and emerging technologies. This course focuses on the microscopic description of heat transfer and energy conversion. It shows how classical physics laws emerge at larger scales and what unique behaviors are observed at the nanoscale.

Content

Part I: Fundamentals (6 weeks)
In the first part of the course we introduce the theory to understand heat transfer and energy conversion at the nanoscale.
1. Energy states

- From classical to quantum harmonic oscillators: material waves and energy quantization (wave-particle duality)
- Energy states in solids (Band structure of crystals, Phonons, Density of states)
- Fundamentals of statistical thermodynamics

2. Energy Transport

- Energy transfer by waves (reflection/transmission and tunneling, energy and momentum of electromagnetic fields)
- Particle description of transport processes (Fourier's law, Newton's shear stress and Ohm's law)

Part II: Size Effects (3 weeks)
In the second part of the course we study the effect of device miniaturization on heat transfer and energy conversion.
3. Classical Size Effects

- Transport parallel and perpendicular to boundaries
- From diffusive to ballistic transport

4. Energy Conversion:

- Carrier scattering, generation and recombination
- Coupled transport and non-equilibrium processes

Part III: Nanostructures for Energy Conversion Devices (5 weeks)
In the third part of the course, starting from recent literature results, we analyze the functioning of selected state-of-the art systems and emerging concepts for energy conversion devices.

5. Thermoelectric devices & materials
6. Nanophotonic Engineering

- radiative heat transfer
- plasmonic photocatalysis
- thermoplasmonics

7. Liquids and Interfaces

- size effects on phase change
- electrokinetic effects in nanochannels
- hydrovoltaic devices

Keywords

Heat transfer, nanoscale systems, energy conversion

Learning Prerequisites

Important concepts to start the course

Fourier's law, Newton's shear stresses and Ohm's law
Wave equation (will be revised)
Classification of materials

Learning Outcomes

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

- Explain and apply the concepts of heat transfer at the nanoscale (E3)
- Describe and explain the particle VS wave picture of energy transport processes
- Analyze the energy transport regimes of an energy conversion device
- Analyze and characterize a light-energy conversion device
- Assess / Evaluate literature reports of state-of-the-art energy conversion devices

Assessment methods

Theory assessed with mid-term written exam
Group project/presentation including literature review

Resources

Bibliography

Nanoscale energy transport and conversion : a parallel treatment of electrons, molecules, phonons, and photons
Gang Chen; 2005
https://library.epfl.ch/beast?record=ebi01_prod004956565

Ressources en bibliothèque

- Nanoscale energy transport and conversion : a parallel treatment of electrons, molecules, phonons, and photons / Chen