Course: Optoelectronics of Surfaces

001.2.4064 (3 CPT)

Course Staff:

Name	Role	address	Tel	Email
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Components of the course grade:

Exercises: Submission of 5 home exercises is mandatory. The score will be 80 pts.

Final Homework: 20 points

Course Description

This graduate-level course offers an in-depth exploration of the physics of surfaces and their central role in optoelectronic phenomena. Students will develop a rigorous understanding of how surface structure and electronic properties govern with/without light–matter interactions, charge transport, and energy conversion processes in modern devices. The course systematically introduces the fundamental principles of surface science, including band structure at surfaces and interfaces, work function, electron affinity, surface dipoles, and band bending, before progressing to advanced topics such as surface photovoltage spectroscopy. A distinctive feature of the course is its integration of theoretical frameworks with experimental methodologies, providing students with the tools to both model and analyze surface-related effects in semiconductors. Emphasis will be placed on applications in surfaces with related optoelectronics properties.

Through lectures, problem-solving sessions, and critical engagement with current literature, students will not only gain mastery of the fundamental physics of surfaces but also learn how to apply these concepts to emerging technologies in energy, sensing, and quantum materials. By bridging solid-state theory and practical device engineering, the course equips students with a comprehensive perspective on the optoelectronics of surfaces, preparing them for research and innovation at the forefront of physics, materials science, and nanotechnology.

Learning Outcomes

By the end of this course, students will be able to:

1. Understand and describe the fundamental physical principles governing surfaces and interfaces.
2. Construct and interpret band diagrams for surface and junction systems.
3. Analyze surface electronic properties such as Fermi level alignment, work function, electron affinity, and dipole formation.
4. Explain surface-related phenomena such as band bending, electric fields, and surface photovoltage.

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5. Apply concepts of surface science to optoelectronic applications including solar cells, photocatalysis, and sensors.

Syllabus

Week	Syllabus per week
1	• Basics of surfaces: atomic structure, reconstructions, dangling bonds. • Importance of surfaces in optoelectronics.
2,3	• Surface states, localized and extended states. • Role of defects and adsorbates.
	• Energy levels at surfaces. • Construction of band diagrams for isolated semiconductors.
4-5	Orbital mixing at surfaces.
	Consequences for electronic density of states.
6	Origins of band bending: charges, surface states, interface traps.
	Effects on carrier transport and recombination.
7	• Poisson's equation and electrostatics at junctions. • Depletion region and built-in potential.
8-10	• Band edge positions and effective masses.
	• Density of states and carrier distribution at surfaces.
11	• Fermi Level, Work Function, and Electron Affinity
	• surface dipoles
12-13	• Physical origin of surface photovoltage (SPV). • Experimental methods for SPV measurement.
	SPV dynamics and spectroscopy

Bibliography in English:

- Molecular Electronics by Chemical Modification of Semiconductor Surfaces, Ayelet Vilan & David Cahen (2016).
- Semiconductor devices: physics and technology, S.M. Sze, M.K. Lee, Publisher: Wiley.
- *Solid Surfaces, Interfaces and Thin Films* (5th ed.) Hans Lüth (2010).