UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Light-to-Electricity Devices, from Silicon Integration to Biological Frontiers

2425-116R-M10

Title

Light-to-Electricity devices, from silicon integration to biological frontiers.

Teacher(s)

Dr. Ottavia Bettucci
Dr. Jacopo Pedrini

Language

English

Short description

The course aims to provide an overview of light-to-electricity devices starting from inorganic semiconductors, with a focus on silicon-based technologies, up to organic semiconductors from small molecules to conductive polymers. We will discuss of optoelectronics in different shapes ranging from on-chip integration to renewable energy, as well as the coupling of electronic devices with biological systems in order to mimic, stimulate, or restore biological behaviours.

LECTURE 1 (2h)
Title: The road to Silicon integration: challenges and perspectives for integrated light sources.
The integration of optical devices onto silicon chips represents a fundamental milestone for numerous technologies. In this lecture, we will describe the fundamental principles of light-matter interaction and highlight challenges and perspectives of this endeavor. The discussion will delve into the technological barriers of achieving on-chip light sources, encompassing material compatibility, fabrication processes, and relevant device design. Furthermore, it will highlight recent breakthroughs such as novel materials and exotic physics for integrated photonics as novel solutions for laser integration.

LECTURE 2 (2h)
Title: The road to Silicon integration: detectors towards advanced applications.
Beyond lasers, other fundamental building blocks of Si-integrated optoelectronic circuits are light detectors. This lecture will discuss the critical role of detectors and the challenges in enhancing their sensitivity and performance. Addressing these challenges involves exploring innovative materials, precise fabrication techniques, and complex designs.
We will analyze breakthroughs in detector engineering and detector technologies, contemplating their implications for advanced applications such as data communication, sensing, and quantum technologies.

LECTURE 3 (2h)
Title: Harnessing organic materials for advanced Light-Harvesting technologies
Organic materials, with their inherent flexibility, tunability, and cost-effectiveness, have spurred innovations in photovoltaics, photodetectors, and optoelectronic applications. This lecture will explore molecular designs and synthetic approaches of conjugated polymers, small molecules, and hybrid materials for efficient light absorption and charge transport. It will investigate the synergy between molecular structure, electronic properties, and device performance, unravelling the mechanisms governing organic-based light-harvesting technologies.

LECTURE 4 (2h)
Title: Empowering biology: organic optoelectronics for precise biological interfaces
Electricity plays a crucial role in biological systems, influencing various physiological processes and enabling vital functions (i.e. ion transport, cell communication, etc). Organic materials, characterized by flexibility, tunability, and biocompatibility, are promising candidates to couple with biological systems. In this lecture, we will explore organic optoelectronic materials and devices capable of interfacing with biological entities enabling precise control and modulation of cellular activities or mimicking biological behaviours.

CFU / Hours

8

Teaching period

April 14 - 2025 h 10.30-12.30
April 15 - 2025 h 10.30-12.30
April 16 - 2025 h 10.30-12.30
April 17 - 2025 h 10.30-12.30

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE