UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Photovoltaics & Other Renewable Energy Technologies

**2425-2-FSM01Q027**

## Aims

The aim of the course is the description of the structure, properties, functions and characterization of materials for solar applications and main renewable technologies. The course will also include the description of the corresponding devices.

**Knowledge and understanding**
At the end of the course the student knows:

- the main solar devices (photovoltaic, artificial photosynthesis, and photoelectrochemical) both commercial and in the research and development stage ;
- the main materials used in them and their main characteristics and properties.
- the main energy production technologies from renewable sources (peculiar photovoltaic applications, wind and e-fuels production)

**Autonomy of judgment**
At the end of this formative activity, the student will have to demonstrate to be able to

- understand the operating principle of a solar device and the relationships between the efficiency of the device and the physical and chemistry properties of the materials used in the device itself;
- understand the main structural characteristics and other properties of the materials used in solar devices;
- critically analyze the reference literature;
- to analyze the advantages and disadvantages and the relative environmental impact of the discussed renewable energy technology.

**Communication skills**
Speaking orally and in writing with language properties of scientific topics of energy materials.

**Ability to learn**
To be able to apply the acquired knowledge on the relationships between material properties and solar device efficiency to examples other than those presented during the course, and to understand the topics covered in the scientific literature concerning materials for energy applications

## Contents

Description of the operating principles of a photovoltaic cell and the properties of the main photovoltaic absorbers and photovoltaic devices currently on the market and in an advanced research and development phase.
Description of the main photocatalytic and photoelectrochemical processes for the production of fuels and chemical compounds from solar energy (e-fuels).
Description of other relevant energy production technologies from renewable sources.

## Detailed program

Sources of energy and renewable sources: an overview. Photovoltaic effect Photovoltaic devices: operation and photovoltaic parameters, theoretical limits of photovoltaic conversion. Measurement techniques and related methodology of analysis of photovoltaic devices (I / V curves under illumination; spectral responses)

Classes of photovoltaic materials and devices:

- Mono and multi-crystalline silicon solar cells (processes of growth and realization of the device)
- Thin film inorganic solar cells (amorphous silicon, CdTe and CIGS): deposition methods and property
- High efficiency solar cells: multi-junction solar cells and concentration systems
- Advanced design solar cells
- Organic and hybrid thin film solar cells (dye-sensitized solar cells, organic-polymeric cells, perovskite cells)
- Materials and devices for photocatalytic and (photo)electrochemical generation of e-fuels and chemical products (artificial photosynthesis, water photolysis, reduction of CO2).
- Wind Energy

## Prerequisites

To optimally follow the course and pass the final exam, basic knowledge of chemistry (general chemistry, inorganic, organic, physical) and solid state physics such as those acquired in the I° study course of materials science are required . In particular, for the 2° part of the class the knowledge of the main chemistry concepts presented in the

scientific courses of the first cycle and basic knowledge (structure, nomenclature, main properties, etc.) of the main chemical compounds are required.

## Teaching form

Lectures in the classroom

Standard lessons supplemented by supporting multimedia tools functional to a better understanding of the practical aspects . In some classes experts coming from industrial sector will be present

23 two-hour lectures, in person, Delivered Didactics

1 two-hour MIBSOLAR laboratory visits, in person, Interactive Teaching

## Textbook and teaching resource

The main texts are for the Prof. Binetti part are

-O. Isabella, K. Jäger, A. Smets , R. van Swaaij,M.Zeman "Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems " UIT ISBN-13: 978-1906860325 ; ISBN-10: 1906860327 (free of charge in EBOOK
-Antonio Luque, Steven Hegedus "Handbook of Photovoltaic Science and Engineering", 2nd edition 2011 John and Wiley & Sons;

Given the nature of the course, which has scientific and technological content very recent there are no exhaustive texts including all the topics.

The students should refer to the slides that the teachers discuss during lectures and which are made available to students in the e-learning platform. The slides also contain references to primary and secondary literature sources (reviews, scientific articles, books) that the student can use to deepen the subject. However, the use of this additional material is not required for passing the exam.

For the second part, held by Prof. Manfredi, the suggested textbook is "Tian H., Boschloo G., Hagfeldt A. (eds) Molecular Devices for Solar Energy Conversion and Storage. Green Chemistry and Sustainable Technology. Springer, Singapore, 2018. " and the relevant literature provided on the e-learning page of the course. It is recalled that the slides contain both the content whose knowledge is considered fundamental for the knowledge of the subject and the passing of the exam and detailed contents that are provided by the teachers in order to better illustrate the subject and support the understanding of the concepts presented. The distinction between the two types is clearly expressed during classroom lessons. In case of doubt it is strongly advised to contact the teachers to know the mandatory parts for the study within the material made available on the e-learning page of the course.

## Semester

Second year, first (fall) semester

## Assessment method

INTERVIEW ON THE TOPICS DEVELOPED DURING LESSONS AND ON THE EXAM TEXTBOOKS

The exam consists of an oral test on all the topics covered in class and reported in the material (slides of the lessons and reference texts) provided to students through the Moodle platform.
During the exam, the teacher can ask the student to write the answers on a piece of paper or on the blackboard, especially if this is necessary (material structures, mechanisms and processes, device configuration, etc.).

Given the nature of the degree course, the exam will focus on materials (structure, properties, functions and characterization) but knowledge on the general structure and characterization of the technoloy and or devices presented during the lessons will also be required.

## Office hours

All days from Monday to Friday upon e-mail request

## Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY