Organic Electronics

Wallenberg Wood Science Center Academy Winter School 2020

Day 1: Fundamental Principles

Introduction to Organic Semiconductors (1.5h)
Lecturer: Mats Fahlman

Content
The course gives an overview of organic semiconductors: their chemical structure, as well as their electronic, optical and magnetic properties. We will also introduce typical materials and basic physical concepts related to their use in applications as well as the "jargon" commonly used the field, including popular acronyms.

Learning outcomes
After the course the participants should be able to demonstrate:

- Knowledge of the general chemical structure and material properties of organic semiconductors.
- Knowledge of names and uses for some typical organic semiconductor materials.
- Knowledge of basic physical concepts related to organic semiconductors and their use in (opto-) electronic devices.
- Knowledge of the field-specific jargon.

Introduction to Organic Electronics (3h)
Lecturer: Isak Engquist

Content
What is organic electronics? Advantages and disadvantages compared to conventional electronics. Organic electronic components. Organic transistors (OTFT, OECT). Organic displays and OLEDs. Fabrication methods. Printed electronics. Commercial products. Market forecast.

Learning outcomes
After the course the participants should be able to demonstrate:

- Ability to explain the working principle of organic transistors of the OTFT and OECT type, and of organic LEDs.
- Knowledge about common processing methods for organic electronics and about common equipment for printed electronics.
- Ability to give examples of commercial products that incorporate organic electronics.

Day 2: Energy

Organic Photovoltaics (1.5h)
Lecturer: Mats Fahlman

Content
The course gives an introduction to organic photovoltaics (OPV). A historical overview of the development of OPVs (materials and device design) is combined with a description of the relevant device physics at a (mainly) conceptual level. We will also introduce some state-of-the-art materials & devices, and comment on future directions for the research and development of OPVs.

Learning outcomes
After the course the participants should be able to demonstrate:

- Knowledge of the general structure and device physics of OPVs.
- Knowledge of names and uses for some typical organic semiconductor materials in OPVs.
- Knowledge of current limitations and challenges for the OPV technology.

Thermoelectrics (1.5h)
Lecturer: Dan Zhao

Content

- Basic concepts and definitions in the field of thermoelectrics.
- Different types of thermoelectric devices.
- Characterization and analysis of thermoelectric materials.
- The state-of-the-art development of thermoelectric materials and applications.

Learning outcomes
After the course the participants should be able to demonstrate:

- Knowledge on basic thermoelectric phenomenon and its applications.
- Understanding on critical parameters of materials with good thermoelectric performance, and typical characterization.

Introduction to Electrochemistry and Energy Storage (3h)
Lecturer: Viktor Gueskine

Content
The course is designed as a rigorous though non-mathematical introduction to the electrochemical vocabulary and ideology for the people with basic knowledge of physical chemistry. It is not designed as a practical introduction to laboratory practice. The following aspects will be covered:

- Thermodynamics basics.
- Equilibrium electrode potential as free energy (Fermi level) of electrons: electrochemical and absolute scales.
- Electrochemical reaction as chemical reaction including a specific reactant: electron from the electrode.
- Real-world electrochemistry: chemistry with electrons + mass transfer.
- Methods: galvanostatic, potentiostatic, linear sweep.
- Charge storage modes: faradaic, capacitive, in between.
- Charge storage devices: batteries, capacitors, pseudocapacitors.
- Various types of batteries.
- Energy - power density (Ragone) plot.

Learning outcomes
After the course the participants should be able to demonstrate:

- Acquaintance with basic ideas and keywords.
- Understanding on similarities and differences between electrochemistry and the rest of chemistry
- Acquaintance with various charge storage possibilities, their advantages and disadvantages.

Day 5: Bioelectronics

Introduction to Organic Bioelectronics (1.5h)
Lecturer: Eleni Stavrinidou

Content
The course will give an overview on organic bioelectronics. Why organic electronic materials are good for translating biological signals? We will introduce organic electrodes and transistors for neural interface and iontronic devices for controlled delivery.

Learning outcomes
After the course the participants should be able to demonstrate:

- Knowledge on basic concepts of organic bioelectronics.
- Knowledge on the advantages of organic materials for interface with biology.
- Knowledge on the basic operation principles of organic bioelectronic devices such as the organic electrochemical transistor and organic electronic ion pump.

Electronic Plants (1.5h)
Lecturer: Eleni Stavrinidou

Content
The course will give an overview on electronic interface with plants with applications in technology but also in biology. We will introduce the concept of direct electronic functionalization of plants with electronic materials for energy and sensing. We will introduce concepts of applying bioelectronic devices to plants for monitoring and controlling plant physiology.

Learning outcomes
After the course the participants should be able to demonstrate:

- Knowledge on basic plant anatomy.
- Knowledge on methods to introduce smart materials in plants and concepts on converting plants to devices.
- Knowledge on applying bioelectronic devices for plants physiology interface.