GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2022-2023

Light and Matter (C004149)

Course size *(nominal values; actual values may depend on programme)*

Credits 4.0 **Study time 120 h** **Contact hrs** 30.0h

Course offerings and teaching methods in academic year 2022-2023

A (semester 2)	English	Gent	lecture	30.0h

Lecturers in academic year 2022-2023

Geiregat, Pieter	WE06	lecturer-in-charge

Offered in the following programmes in 2022-2023	**crdts**	**offering**
Master of Science in Teaching in Science and Technology(main subject Chemistry)	4	A
Master of Science in Chemistry(main subject Analytical and Environmental Chemistry)	4	A
Master of Science in Chemistry(main subject Materials and Nano Chemistry)	4	A
Exchange Programme in Chemistry (master's level)	4	A

Teaching languages

English

Keywords

Light, Matter, Photonics, Lasers, Spectroscopy, Non-linear Spectroscopy, Molecules, Semiconductors, Nanomaterials, Rapid Polymer Prototyping

Position of the course

Light and Matter is an optional course in the master in Chemistry program dealing with the interaction of electromagnetic radiation (light) with matter, where both linear and non-linear interactions with molecular, bulk and nanostructured materials will be discussed. These unique and often unexpected interactions of light with matter form the basis of many advanced optical spectroscopy instruments, such as ultrashort pulsed lasers, and methods that allow physical chemists to map out chemical reaction dynamics and probe the transient behavior of elementary excitations in matter on the relevant, i.e. femtosecond (10^{-15} s), timescales. The unique light sources used for such experiments also find application in microfabrication of polymers, e.g. in tissue engineering. The course will build on 12 weeks of theory lectures, supplemented by research papers and invited lectures of experts in the field.
The course addresses the following competences:

CBCHMI1.1
Kennis hebben van algemene begrippen, concepten, theorieën en principes van de anorganische, fysische, organische, macromoleculaire en analytische chemie en deze toepassen op eenvoudige problemen.

CBCHMI1.2
Basiskennis en inzicht hebben in andere wetenschappelijke disciplines en ze toepassen in de chemie

CBCHMI1.3
Kennis hebben van methodes en technieken voor chemische analyse en voor studie van chemische processen en ze toepassen.

CBCHMI1.8(C&B)
Kennis hebben van algemene begrippen en theorieën in een andere vakgebied en deze toepassen op eenvoudige problemen.

CBCHMI2.3
Wetenschappelijke literatuur evalueren, raadplegen en benutten.

CBCHMI3.5
Eigen handelingen bijsturen op basis van kritische reflectie.

CBCHMI4.1
Schriftelijk en mondeling rapporteren over een wetenschappelijk onderwerp aan vakgenoten en aan niet-vakgenoten.
CBCHMI4.2
Communiceren in de eigen taal en in het Engels.
CBCHMI4.4(C&T)
Schriftelijk en mondeling rapporteren over een chemisch-technologisch onderwerp
CBCHMI4.6(C&B)
Discussiëren over wetenschappelijk onderzoek, uitgevoerd interdisciplinair tussen chemie en een ander vakgebied.

Contents

1 Classical view on linear interactions of light with matter: Maxwell's equations in solids, material dispersion,local field factors, Kramers-Krönig relations, light assorption/refraction and the Lorentz oscillator model.
2 Bulk semiconductors (interband transitions, excitons) and metals (plasmons).
3 Nanostructured materials: quantum dots, quantum wells, intraband transitions.
4 Luminescent molecules and color centers.
5 Quantum view on linear light-matter interactions: Photons and Planck's law, Einstein coefficients, stimulated and spontaneous emission, the oscillator strength.
6 Classical view on non-linear interactions of light with matter: second order non-linearities (second harmonic generation/sum frequency generation), third order non-linearities (Kerr effect, Raman scattering) and applications of non-linear optics in optical spectroscopy.
7 Advanced light sources: lasers, ultrashort pulsed lasers, supercontinuum sources.
8 Materials spectroscopy 1: Pump-probe spectroscopy and femto-chemistry
9 Materials spectroscopy 2: Femtosecond luminescence, advanced probes (THz, Infrared, Electron scattering, ...)
10 Lab session and/or invited lecture on advanced optical spectroscopy applied to novel materials.

Initial competences

- Fysica: elektromagnetisme (C003980)
- Elektronische structuur (C003972)
- Spectroscopische analysemethoden (C003977)
- Chemische structuren (C003964)

Final competences

1 Extensive knowledge of linear and non-linear interactions of light with matter, both in bulk, molecular and nanostructured systems.
2 Have a working knowledge of advanced light sources and their use in chemistry.
3 Detailed knowledge of the possibilities and limitations of ultrafast optical spectroscopy in materials development.
4 Critical attitude towards scientific literature.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture

Extra information on the teaching methods

Lectures, demonstration and project.

Learning materials and price

English language course text, slides and a selection of recent papers from literature. Student presentations. Estimated cost: 15 EUR

References

- Optical Properties of Solids, M.Fox
- Luminescence Spectroscopy of Semiconductors , I. Pelant
- The Quantum Theory of Light, R. Loudon

- Non-linear optics, R. Boyd
- Theory of Optical Processes in Semiconductors: Bulk and Microstructures, P.K. Basu

Course content-related study coaching

Interactive support by means of Ufora. Questions and discussions during and after the classroom lectures. Personal assistance for the preparation of presentations, if required.

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Report, Oral examination

Examination methods in case of periodic assessment during the second examination period

Examination methods in case of permanent assessment

Report

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

Presentation of a topic of choice during lectures series.
Oral exam on work assignment and presentation.

Calculation of the examination mark

To be evaluated, each student has to write and present a review discussing a recent publication on a topic related to the course. The review is written in a two-step process. Only after a first version has been peer-reviewed by fellow students, a second version is submitted for evaluation. The evaluation is based on the written report, the presentation and the discussion following the presentation. A single mark is given for the whole of written report, presentation and discussion.