APPL 435
Nanophotonics
Spring 2020

Course description

This course introduces the principles of nanophotonics – an emerging frontier at the nexus of nanotechnology and photonics. Nanophotonics deals with light-matter interactions on the nanometer scale (1-100 nm). Traditional photonic components and devices cannot work at this length scale due to the diffraction of light, which fundamentally limits the propagation and confinement of light in a free space. Nanophotonics addresses this challenge by developing new experimental tools and computational methods to fabricate and characterize optical nanostructures, and use them to manipulate light at the sub-wavelength scale. Nanophotonics thus provides enormous opportunities for fundamental research and new applications, such as nanolasers, plasmonic biosensors, and photothermal therapy.

This course aims to provide a comprehensive view of nanoscale optical materials and photonics to undergraduate and graduate students by starting at a very elementary level, and gradually guiding the students to the very frontier of current research in nanophotonics. In addition to the basic concepts, you will learn experimental techniques and simulation methods on light interactions with nanostructures. It is expected that you can apply your new knowledge to read and understand the current scientific literature in the fields of nanophotonics after you complete this course.

The principles and technology that you will learn will give you a glimpse of the "bright" nanoscale world. However, that is not the sole objective of this class. An important goal of this course is to help you develop an entrepreneurial mindset by connecting nanophotonics with your major, so you may recognize opportunities by applying the nanophotonic materials and techniques to your future study and career. We will have a variety of in-class and lab activities that give you a chance to think and apply the knowledge that you learn. Think about the bigger picture and be prepared to participate in these activities!

Logistics

Contact information:
Instructor: Dr. Zijie Yan
Email: zijieyan@unc.edu
Office location: Caudill 159

Office hours:
Tuesday/Thursday 2:00-3:00 pm

TA contact information:

TBD

Class meeting location and times:
TBD

Textbook and other instructional materials:
The following books are recommended as references. They are available in UNC libraries. We will select chapters from these books and provide additional course materials.

1. Nanophotonics, *by Paras Prasad (ebook)*
2. Plasmonic Biosensors: An Integrated View of Refractometric Detection, *by A.B. Dahlin (ebook)*
3. Introduction to Nanophotonics, *by S. V. Gaponenko (book)*
4. Principles of Nano-Optics, *by Lukas Novotny and Bert Hecht (book)*
5. Nanophotonics: Accessibility and Applicability, *by National Research Council (ebook)*

Online resources:
Lecture slides and other course materials will be posted on Sakai. We will use Poll Everywhere in the class.

Prerequisites:
PHYS117 or CHEM251 for undergraduates; none for graduate students

Target audience:
This course will be most suitable for juniors, seniors and graduate students in Physics, Chemistry, Biomedical Engineering, Applied Physical Sciences and related majors.

Policies

I expect all students to

- Come to every scheduled class and lab session and let me know ahead of time if you cannot attend lab.
- Avoid use cell phones unless for Poll Everywhere
- Turn in assignments on time; if an assignment is up to 24 hours late, there is a 25% deduction, and if an assignment is beyond 24 hours late, you will get a zero. If you need an extension, you must ask at least 24 hours before the time that the assignment is due (you can avoid a grade deduction this way).

Honor code

I will let you know if an assignment should be done individually or as part of a group. While I encourage you to help each other for individual work, it is a violation of the honor code if you copy or obtain solutions from another student.

Student learning outcomes

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

- Identify different types of materials and know their typical optical properties
- Predict the optical properties of a material based on its dielectric function
- Understand the atomic mechanisms of different optical phenomena, such as absorption, scattering and emission
- Perform electrodynamics simulations using software
- Select suitable tools to fabricate and characterize nanostructures
- Understand the plasmonic principles to guide and focus light below the diffraction limit
- Explain the functions of plasmonic biosensors
- Understand the plasmon-driven photochemistry
- Interpret optical forces on nanostructures in optical tweezers
- Distinguish different types of nano-emitters for biological applications

Class topics:

- Week 1: Introduction – nanophotonics at a glance
- Weeks 2-3: Foundations for nanophotonics: materials and optics
- Week 4: Fabrication of optical nanostructures
- Week 5: Characterization techniques for nanophotonics
- Weeks 6-7: Plasmonics: guiding and focusing of light below the diffraction limit
- Week 8: Modeling of light-matter interactions at the nanoscale
- Week 9: Light generation by nanostructures
- Week 10: Optical manipulation of nanostructures
- Week 11: Applications of nanophotonics: photochemistry and bioimaging

Grading

Your final grade will be determined based on the following weights:

- Homework: 30%
- Projects: 25%
- Quizzes (2): 20%
- Presentations/final report: 25% (No final exam)

At least two projects are expected, one on experiments and the other on simulations; and two presentations will be required, one is a literature review of a current research topic in nanophotonics, and in the other (the final presentation) you will introduce an article on nanophotonics published recently in one of the leading journals, and write a report with a critical review of the paper (assuming you are a reviewer for a submitted manuscript).

Major course due dates:

- Quiz 1: TBD

- Quiz 2: TBD

Final letter grades will be calculated with the following grade scale:

Undergraduate	Graduate
A: >90.0 A-: 87.0-89.9 B+: 83.0-86.9 B: 80.0-82.9 B-: 77.0-79.9 C+: 73.0-76.9 C: 70.0-72.9 C-: 67.0-69.9 D+: 63.0-66.9 D: 60.0-63.0 F: <60.0	H: >87.0 P: 73.0-86.9 L: 60.0-72.9 F: <60.0

Accommodation for students with disabilities

The University of North Carolina – Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in difficulties with accessing learning opportunities. All accommodations are coordinated through the Accessibility Resources and Service Office. Please visit http://accessibility.unc.edu for more information.

Syllabus changes

I reserve to right to make changes to the syllabus, including project due dates and test dates, when unforeseen circumstances occur. These changes will be announced as early as possible so that students can adjust their schedules.