APPLIED PHYSICAL SCIENCES

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

APPL 435-001 Draft Syllabus

Nanophotonics

Spring, 2021

Introduction	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.
Methods	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.
Results	*By the end of this course, students should be able to:* • Identify different types of materials and explain their typical optical properties • Predict the optical properties of a material based on its dielectric function • Distinguish the atomic mechanisms of different optical phenomena, such as absorption, scattering and emission • Perform electrodynamics simulations on nanophotonic structures using software • Select suitable tools to fabricate and characterize nanostructures • Explain the plasmonic principles to guide and focus light below the diffraction limit • Design plasmonic biosensors • Apply metal nanomaterials for plasmon-driven photochemistry • Interpret optical forces on nanostructures in optical tweezers • Distinguish different types of nano-emitters for biological applications
Discussion	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!

Engineering Student Outcomes	By the end of this course, students will gain experience in the following engineering student outcomes: • integrate information from many sources to gain insight. • identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics • communicate effectively with a range of audiences • develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.

Class Essentials

➢ CONTACT INFORMATION

Dr. Zijie Yan

Office Location
Caudill 159

Email
zijieyan@unc.edu

Phone
9198435056

Teaching assistants

(not applicable)

➢ LOGISTICS

Class meeting times
Tuesday/Thursday 2:00-3:15 pm

Class meeting location
Join Zoom Meeting
https://unc.zoom.us/j/97569197203?pwd=NmhLVU0wNXR5WkVIc2orMFRBQVZDdz09

Meeting ID: 975 6919 7203
Passcode: 435001

Office Hours
by appointment

Required Texts & Software

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

- We will use Lumerical FDTD for simulations. Student license will be provided.

Pre-requisites

- no pre-requisites for Spring 2021 semester enrollment

Course content

➢ Course Topics

- Topic 1: Introduction – nanophotonics at a glance
- Topic 2: Foundations for nanophotonics: materials and optics
- Topic 3: Growth and fabrication of optical nanostructures
- Topic 4: Characterization of nanomaterials
- Topic 5: Plasmonics: from fundamentals to modern applications
- Topic 6: Simulation of light-matter interactions at the nanoscale
- Topic 7: Quantum emitters for bioimaging and super-resolution microscopy
- Topic 8: Gripped by light: optical forces on nanomaterials

➢ Course Schedule

For week-by-week schedule, see link on Sakai

To help you succeed

➢ Course Expectations and Policies

All students are expected to

- Come to every scheduled Zoom meeting as there might be discussions and activities
- 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).

➢ Student Resources

SEE, SAY, DO SOMETHING

We're happy you are here and eager to learn. Despite our best intentions to follow a plan, life may throw us a curve ball. If you or someone you know is experiencing some distress or you are concerned about the well-being of a student, please report it here: https://deanofstudents.unc.edu/carereport. It is important to support one another. If you see something, say, and do something.

ACCESSIBILITY RESOURCES

UNC-CH provides accommodations for any students with documented disabilities. If you have a disability and believe you require accommodations, please contact the Department of Accessibility Resources at http://accessibility.unc.edu. Please contact me early in the semester so we can make any necessary arrangements and discuss the learning checks.

Assignments & Evaluation

➢ YOUR COURSE GRADE	
35%: Homework	We will have one homework assignment typically after one or two topics
15%: Project	We will have a design project based on FDTD simulations
30%: Exams	We will have two open-book, open-note exams
20%: Presentations + final report	We will have two presentations. One is a literature review of a current research topic in nanophotonics. The other one requires you to present 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 the submitted manuscript).
100%: total	

➢ GRADE INTERPRETATION & HONOR CODE	
Your final course grade will be determined from a standard scale: **A** 93+ **A-** 90.0 - 92.9 **B+** 87.0 - 89.9 **B** 83.0 - 86.9 **B-** 80.0 - 82.9 **C+** 77 - 79.9 **C** 73 - 76.9 **C-** 70 - 72.9 **D+** 67 - 69.9 **D** 60 - 66.9 **F** <60	**ACADEMIC HONESTY** There will be clear communication if assignments are individual or group. For individual assignments, while I encourage collaboration, it is a violation of the honor code if a student duplicates work or obtains solutions from another student and submits it on their own. Please reference the honor code: http://honor.unc.edu.

➢ MAJOR COURSE DUE DATES	
Exam 1	TBD
Exam 2	TBD

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