

EE 599-003: Nano-Photonics

Fall 2009

Instructor:

Prof. J. Todd Hastings
office: 352 AStECC Building
phone: 859-218-6544
e-mail: hastings@engr.uky.edu

Web-site: <http://courses.engr.uky.edu/ECE/ee599-005/>

Class Meeting: 12:00pm-12:50pm, MWF, 267-FPAT

Office Hours: Mondays and Thursdays, 2:00pm – 3:00pm, or by appointment.

Texts:

Class notes will be the primary source of information.

Reference texts of interest include

1. *Principles of Nano-Optics* by Novotny and Hecht
2. *Nanophotonics* by Prasad available at <http://ezproxy.uky.edu/login?url=http://www.netlibrary.com/urlapi.asp?action=summary&v=1&bookid=119141>
3. *Absorption and Scattering of Light by Small Particles* by Bohren and Huffman
4. *Diode Lasers and Photonic Integrated Circuits* by Coldren and Corzine
5. *Fundamentals of Photonics* by Saleh and Teich
6. *Waves and Fields in Optoelectronics* by Haus
7. *Optical Electronics in Modern Communications* by Yariv

Grading:

Homework	20%
Exam 1	25%
Exam 2	25%
Final Project	30%

Prerequisites:

Basic math and physics for engineers.

Objectives and Outcomes:

Upon completion of this course students should demonstrate the ability to:

1. Understand dielectric waveguides. Specifically, students should be able to calculate propagation constants, dispersion relations, and field profiles for single mode

and multimode 1D and 2D structures and should understand the various sources of loss in optical waveguides. Students should also be able to analyze coupled waveguides.

2. Understand integrated optical resonators. Specifically, students should be able to calculate resonance frequencies, Q-factors, and reflection and transmission spectra for optical cavities of various geometries.

3. Understand the operation of passive integrated photonic devices (i.e. couplers, filters, dispersion compensators) and active integrated photonic devices (i.e. lasers, modulators, switches).

4. Understand photonic crystal structures. In addition to the concept of a photonic band gap, students should understand the mechanism of defect induced waveguides and resonant cavities.

5. Understand surface-plasmon optics. Specifically, students should be able to calculate dispersion relations for 1D and 2D metallic surface-plasmon waveguides. Students should be able to calculate the extinction, scattering, and absorption cross sections of metallic nanoparticles supporting surface-plasmon modes. Students should understand the operation of surface-plasmon resonance sensors based on both thin films and nanoparticles. Students should understand the application of surface-plasmon photonics to microscopy and lithography.

6. Understand the properties of nanostructured optical materials including quantum confined structures and meta-materials. Specifically, students should be able to estimate the emission properties of quantum confined structures and understand how microscopic material structure can lead to interesting effective bulk optical properties.

Final Project:

The final project for this class will give you the opportunity to delve deeper into a current topic in micro- or nano- photonics that interests you. The final project will be evaluated based on both a written report and an in class presentation. The report and presentation should include:

1. A brief introduction to the topic that highlights goals of the work and major challenges.
2. A review of current research in the area citing appropriate papers.
3. For undergraduate students: An independent *analysis* of some aspect of the topic to pose and answer a “what if?” question. Examples: How would the properties of a grating-based integrated optical filter change if the waveguide were made from Si_3N_4 instead of Si? Or, how would the sensitivity of a nanoparticle based optical sensor change if the particles were made from silver instead of gold?
4. For graduate students: An independent *design* for a micro- or nano-scale photonic device (related to your chosen topic of course) that considers performance targets, design trade-offs, and sources of error.

Homework:

Homework is essential to understand the material presented in this course. Students will typically have one week to complete homework assignments. Assignments will be distributed on the course web-site. Assignments must be submitted by 5pm on the due date. No late homework will be accepted. If a student will be absent from class he or she

should submit the homework early or make arrangements for another student to submit it. Solutions will be available on the course website after the due date.

Students are allowed and encouraged to work together on the homework, but each student must submit an individual solution set. If a student learns the solution to a problem from another source (human, printed, electronic, etc.), this should be documented in the submitted homework. Directly copying a solution from another student or source is not permitted.

Computer Usage:

Certain homework problems will be most readily solved using a computer. MATLAB is the recommended, but not required, software package for solving these problems, and all solutions will be provided in MATLAB format. In addition, sample MATLAB files will be provided for many problems. MATLAB is available in the following computer laboratories: Civil Engineering Lab, Agriculture Lab, Anderson Hall Lab, and Chemistry Physics Lab.

MATLAB is in widespread use both in education and industry. Its combination of a straightforward scripting language, a large library of compiled functions, and powerful graphics capabilities allows one to rapidly write useful code. You will find knowledge of MATLAB to be helpful for other courses as well as your future career.

Exams:

There will be two exams given in-class. Failure to take an exam will result in a grade of zero for that exam. Permission to take the exam at a different time may be granted if and only if the student contacts the instructor **before** the exam date.

Class Attendance:

Students are responsible for all business conducted during scheduled class periods. Announcements concerning homework, exams, and schedules will be made during class.

Academic Offenses:

Cases of cheating or plagiarism will be handled according to the rules in the University of Kentucky *Student Rights and Responsibilities*. If there is any question as to what constitutes cheating or plagiarism please consult the instructor.