OSE6650 Optical Properties of Nanostructured Materials – Spring 2020

Class times	Tuesdays & Thursdays 3pm-4:15pm / simulation sessions (see schedule)
Room	CREOL A214
Instructor	Dr. Pieter G. Kik, Office A220, CREOL Building Phone 407-8234622, e-mail kik@creol.ucf.edu
Website	https://webcourses.ucf.edu
Office hours	Tuesdays and Thursdays 4:30pm – 5:30pm
Prerequisites	OSE5111 *Optical Wave Propagation* and OSE5312 *Light Matter Interaction* or consent of instructor (COI)
Catalog description	*Theory and applications of nanostructured optical materials: effective medium theory, nanostructured surfaces, plasmon waveguides, nanophotonic circuits, metallic near-field lenses, collective modes in nanoparticle arrays, metamaterials.*

Detailed description

This course covers topics dealing with the optical properties of nanostructured materials. In the first part of the course we will discuss effective medium theory, including the Maxwell-Garnett description of the refractive index of inhomogeneous materials. We will cover applications of nanostructured dielectrics, including metasurfaces and metalenses based on propagation phase and geometric phase. The second part of the course deals with the optical properties of nanostructured metallodielectric materials. We will introduce the concept of localized surface plasmons (LSPs) on metal nanoparticles, and discuss spectral control of the plasmon resonance frequency by tuning shape, size, and dielectric environment. This is followed by applications of LSPs, including surface enhanced Raman scattering (SERS) and index-based biosensing. The third part of the course covers electromagnetic surface waves known as surface plasmon polaritons (SPPs), and discusses the use of surface plasmon resonance (SPR) for biodetection. Finally, we briefly discuss the concept of metamaterials: composite materials that have been nanostructured to obtain a specific dielectric response. We will discuss how this can give rise to negative refraction, and we will discuss an early experimental realization of this concept.

The course concludes with a substantial hands-on simulation component with industrial level electromagnetics design software. Students choose a nanophotonic structure related to one of the topics covered in class, and investigate its optical response numerically. This allows direct visualization of several concepts covered early in the course.

Optional textbooks

- "*Plasmonics*", S. A. Maier
- "*Surface Plasmon Nanophotonics*", M.L. Brongersma and P.G. Kik, Eds.
- "*Principles of Nano-Optics*", Novotny and Hecht
- "*Surface plasmons on smooth and rough surfaces and on gratings*," H. Raether
- "*Near-field optics and surface plasmon polaritons*," Edited by: Satoshi Kawata

Assessment

Homework	15%
Midterm	25%
Paper presentation	25%
Simulation project	35%

Preliminary schedule – please always check the most recent schedule on the course website

Date	Subjects covered
1-7	Introduction / overview
1-9	Effective index of nanostructured materials
1-14	Metasurfaces
1-16	Near-fields and Near-field Microscopy
1-21	Localized surface plasmon resonances on metallic nanospheres
1-23	Localized surface plasmon resonances - effect of particle size and host index
1-28	Localized surface plasmon resonances - effect of particle shape + core-shell NP
1-30	Inter-particle interactions : nanoparticle waveguides and cascaded resonances
2-4	Applications of LSPs : biodetection 1 - SERS
2-6	Applications of LSPs : biodetection 2 - wavelength shift, tracers
2-11	Surface plasmons on planar metal films - dispersion relations
2-13	Surface Plasmon excitation and detection 1: near-field / grating / prism coupling
2-18	Surface Plasmon excitation and detection 2: practical examples
2-20	SPASERS
2-25	Metamaterials and negative refraction
2-27	Photonic bandgap materials - basic principles, line and point defect modes
3-3	**PRESENTATIONS Room 103 - 9am - 11am**
3-5	Pre-midterm recap
3-10	Spring Break
3-12	Spring Break
3-17	**Midterm exam**
3-19	Midterm results discussion / Fundamentals of EM simulation
3-24	Simulation session, Introductory simulation
3-26	No lecture
3-31	Simulation session, Start of own project
4-2	No lecture
4-7	Simulation session
4-9	No lecture
4-14	Brief project presentations, final simulation session
4-16	No lecture
4-23	**Final report due**