OSE 6650
Optical Properties of Nanostructured Materials
College of Optics and Photonics, University of Central Florida

COURSE SYLLABUS

Instructor:	Pieter G. Kik	Term:	Spring 2022
Office:	CREOL A220	Class Meeting Days:	Monday / Wednesday
Phone:	407-823-4622	Class Meeting Hours:	3:00 PM – 4:15 PM
E-Mail:	kik@creol.ucf.edu	Class Location:	A214
Website:	https://webcourses.ucf.edu	Office Hours:	Monday / Wednesday 4:30 PM – 5:45 PM

I. University Course 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

II. Course Overview

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.

III. Course Objectives and Outcomes

The students will have a basic understanding of plasmonics, nanophotonics, and metamaterials. There will be detailed discussions about the physics and optics of various nanophotonics structures. The students will be able to use the knowledge gained in this course to numerically simulate nanophotonic elements, which will enable them to further their research and enhance existing technologies.

IV. Course Prerequisites

OSE5111 Optical Wave Propagation and OSE5312 Light Matter Interaction, or consent of instructor (COI)

V. Course Credits

3 (3,0)

VI. Suggested Texts and Materials

"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

VII. Topics Covered

- Effective index of nanostructured materials
- Metasurfaces and metalenses
- Near-fields and Near-field Microscopy
- Localized surface plasmon resonances on metallic nanospheres
- LSP resonances - effect of particle size and host index
- LSP resonances - effect of particle shape and radial composition
- LSP on metal ellipsoid / LSP on dielectric-core/metal-shell NP
- SPPs on planar metal films - dispersion + prism coupling
- Surface Plasmon excitation and detection 1
- Plasmon mediated biodetection, SERS, wavelength shift, tracers
- Metamaterials and negative refraction
- Photonic bandgap materials - basic principles, line and point defect modes

VIII. Basis for Final Grade

Assessment	Percent of Final Grade
Homework / simulation exercises	40%
Paper presentation	20%
Final project	40%
	100%