ECE 4223: Nanophotonics

Credits and contact hours: 3 Credits

Instructor: Eric Donkor

Textbook: Optical Metamaterials, Wenshan Cai and Vladimir Shalaev, Springer
Plasmonics: Fundamentals and Applications; Stephan A. Maier, Springer

a. Other supplemental materials: Instructor’s web-based notes

Specific course information:

a. Catalog Description: Principles and applications of nanophotonics with focus on optical metamaterials, plasmons, and photonic bandgap crystals. Topics covered include electric plasma, magnetic plasma, optical magnetism, negative index metamaterials, localized and non-localized surface plasmon polaritons, photonic bandgap structures, superlens, optical cloaking.

b. Prerequisite: ECE 3223, open only to students in the school of engineering

c. Required, elective, or selected elective: Elective

Specific goals for the course:

a. Specific outcomes of instruction: Students will be able to:
   - apply principles of physical optics to analyze light propagation in optical metamaterials, plasmonic structures, and photonic crystals.
   - Employ analytical models such as Maxwell-Garnett Theory, Bruggemann Effective Medium Method, to determine the effective permittivity and effective permeability of nanoscale dielectric-metal, and dielectric-dielectric composite materials.
   - Analyze the optical characteristic of electric metamaterials, magnetic metamaterials, negative-index metamaterials, plasmonics structures, and photonic crystals
   - Describe the principles underlying nanophotonics applications such as optical cloaking, plasmonic sensors, photonic crystal fibers.

b. ABET Criterion 3: Student Outcomes addressed by the course:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
   Design and open-ended problems in nanophotonic applications requires students to be able to formulate and solve problems using analytical or simulation tools.
2. an ability to apply engineering design to produce solutions that meet specified needs with considerations of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

3. an ability to communicate effectively with a range of audience
   Students learn to communicate through in-class oral presentation and technical report on an assigned topic in nanophotonics

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. an ability to function effectively on a team whose members together provide leaderships, create a collaborative and inclusive environment, establish goals, plan task, and meet objectives

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusion

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
   Students research and write a technical report on topics focusing on emerging trends in nanophotonics, by referencing published technical reports and archival journals in nanophotonics.

Topics covered:
- Optical properties of metal-dielectric composites
- Electric metamaterials
- Magnetic metamaterials
- Negative-index metamaterials
- Surface plasmon polaritons
- Propagating and localized surface plasmon waves
- Optical cloaking
- Optical nanoantennas
- Surface plasmon sensors
- Photonic Crystal fibers