ME 495 (31)

Fundamental and Applications of Metamaterials  
- Electromagnetic, Acoustic, and Mechanical

Spring 2019

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**Lecture: Office Hour:**

**Time:** MW 11:00am-12:20pm **Time:** by Appointment

**Location**: https://northwestern.zoom.us/j/910337063

**DESCRIPTION**

Metamaterials that mimic the order in matters have opened an exciting gateway to reach unprecedented physical properties and functionality unattainable from naturally existing materials. The "atoms" and "molecules" in metamaterials can be tailored in shape and size, the lattice constant and inter-atomic interaction can be precisely tuned, and "defects" can be designed and placed at desired locations. Recent studies have demonstrated engineering metamaterials with unprecedented characteristics such as left-handedness with simultaneous negative permittivity and permeability, negative lens that focus electromagnetic waves far below the diffraction limit, artificial magnetism from nonmagnetic materials, and invisibility cloaking of electromagnetic energy.

This introductory course is designed to cover the technology fundamentals of the optical and mechanical metamaterials, micro-/nano-fabrication methodologies, and prospective applications. Specific topics include sub-wavelength waveguiding and focusing, super-resolution imaging and nano-lithography beyond the diffraction limit of the light, negative refraction, and invisibility cloaking. Plasmonic metamaterials, bio- sensing, enhanced Raman scattering, extraordinary transmission, Graphene Plasmonics, light-trapping for solar cell will also be discussed.

**GRADING**

60% presentation + 40% report (5 pages)

Course project in the form of literature review will be required in this class. Find the topics related to Metamaterials and search for the relevant articles. You should provide a comprehensive background description, major achievements or observation of the articles in your presentation and report. Try to relate what you have read to what we have discussed in class. It is recommended to choose the topic in relevant to your own research interest. It is critical to include critiques and perspectives from your point of view.

**PREREQUISITES**: Basic knowledge of electromagnetism and mechanical waves.

**RECOMMEND TEXT BOOKS:**

1. *“Optics,” Hecht (Addison Wesley, 1990)*
2. *“Classical Electrodynamics” J. D. Jackson (John Willey & Sons, 1999)*
3. *“Photonic Crystals: Molding the Flow of Light,” J. D. Joannopoulos, R. D. Meade, J. N. Winn (Princeton University Press, 1995)*
4. *“Surface plasmons on smooth and rough surfaces and on gratings”, H. Raether (Springer, 1988)*
5. *“Plasmonics: Fundamentals and Applications”, S. Maier, (Springer, 2007)*

**COURSE OUTLINE** (Tentative):

Week 1: Light interaction with matter. Review of the Maxwell’s equations.

Week 2: Photonic and Phononic Bandgap Structure

Week 3: Introduction to Metamaterials

Week 4: Negative Index Materials

Week 5: Surface Plasmon Polaritons

Week 6: Cloaking objects with metamaterials.

Week 7: Acoustic metamaterials and Mechanical Metamaterials

Week 8: Super resolution, Near-field Scanning Optical Microscopy.

Week 9-10: Presentations