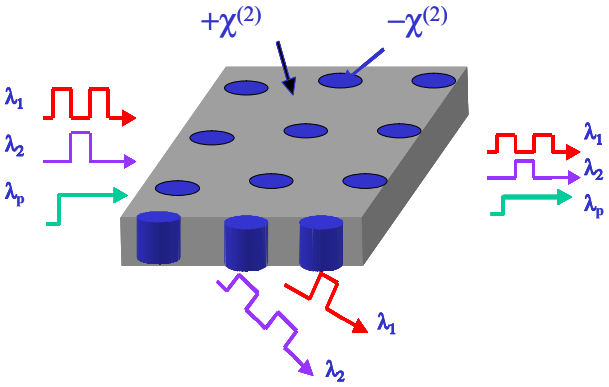
Lehigh ECE Course ECE 350/450
Physics and Applications of Photonic Crystals
Instructor: Professor Nelson Tansu, Ph.D.
Abstract:

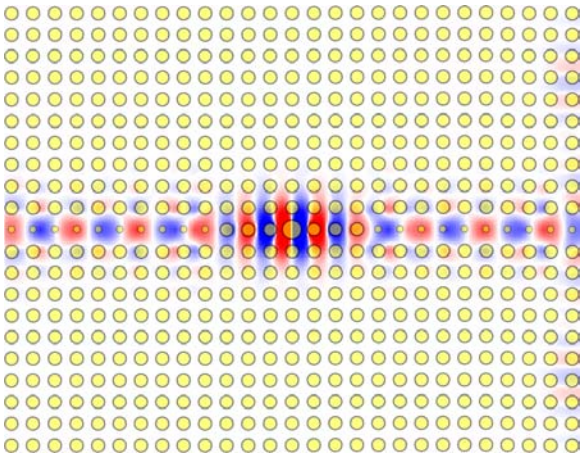
The course will emphasize on the fundamental physics of linear- and nonlinear-photonic-crystals, challenges in fabrication of photonic crystals material and devices, and various applications of photonic crystal devices. Photonic crystal structures allow the ability to engineer the electromagnetic properties of various materials by creating a photonic band gap. Linear and nonlinear photonic crystals allow various applications in molding the flow of light, which were otherwise not possible. Simulations would also be utilized for homework and projects. Applications of both linear and nonlinear photonic crystals devices will be extensively covered. This course is intended for **upper-undergraduate and first-year graduate students** in electrical engineering, physics, material science engineering, and others, who are interested in photonics & semiconductor optoelectronics. Strong background in ***undergraduate-level*** electromagnetic, optoelectronics, and semiconductor devices is required.

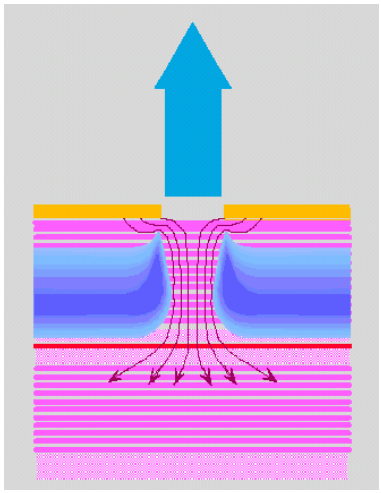
Prerequisite: ECE courses in 'Upper-Level Electromagnetics', 'Integrated Optics'.

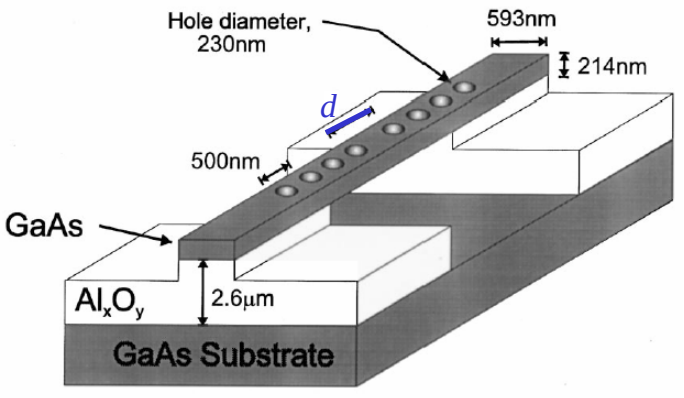
Grading:

Homework	50 %
Mid Term	20 %
Final Project/Presentation	30 %









Required Materials:

1. Lecture notes and journal papers.

Recommended Books:

1. Kazuaki Sakoda, "Optical Properties of Photonic Crystals," Springer Verlag, 2001.
2. Pochi Yeh, "Optical Waves in Layered Media", Wiley, 1988.
3. Steven G. Johnson, and John D. Joannopoulus, "Photonic Crystals: The Road from Theory to Practice," Kluwer Academic Publishers, 2002.
4. R. E. Slusher, and B. J. Eggleton, "Nonlinear Photonic Crystals," Springer Verlag, 2002.

Syllabus (8 topics – 15 weeks):

1. Overview of the Course
   - 1.1 Linear Photonic Crystals
   - 1.2 Technology and Fabrication of Photonic Crystals
   - 1.3 Photonic Crystals Devices
   - 1.4 Physics and Applications of Nonlinear Photonic Crystals
   - 1.5 Quantum Optics
2. Physics of Linear Photonic Crystals
   - 2.1 Maxwell's Equations
   - 2.2 Bloch's Theorem
   - 2.3 Photonic Band Gap and Localized Defect States
   - 2.4 Transmission Spectra
   - 2.5 Nonlinear Optics in Linear Photonic Crystals
3. Guided Modes in Photonic Crystals Slab
   - 3.1 Computational EM Techniques
   - 3.2 Simulation with MIT Photonic Band Gap Software
   - 3.3 Examples : Experimental Simulation with the Software for Various PBG Structures
4. Technology, Materials, and Fabrication of Photonic Crystals
   - 4.1 Choices of Materials : Semiconductors, Amorphous, and Polymers
   - 4.2 Fabrications of Photonic Crystals Structures (1-D, 2-D, 3-D)
5. Applications of Photonic Crystals Devices
   - 5.1 DBRs: 1-D Photonic Crystals
   - 5.2 Couplers, Waveguides, High-Q Cavities, etc: 2-D Photonic Crystals
   - 5.3 Photonic Crystal Fibers
   - 5.4 Tunable Photonic Crystal Filters
6. Physics of Nonlinear Photonic Crystals
   - 6.1 1-D Quasi Phase Matching
   - 6.2 Nonlinear Photonic Crystal Analysis (following Berger's PRL manuscript)
7. Applications of Nonlinear Photonic Crystals Devices
   - 7.1 Materials : $LiNbO_3$, Chalcogenide Glasses, etc
   - 7.2 Wavelength Converters, etc
8. Optional Topics :
   - 8.1 Photonic Crystals Active Devices (ie. Photonic Crystals Lasers and VCSELs)
   - 8.2 Quantum Optics in Photonic Crystals