ENMA 443: Photonics (Elective) – 3 credits

Class Schedule: Monday and Wednesday, 3:30PM – 4:45PM

Instructor: Prof A. Christou

Textbook:

Catalog Description: The course focuses on the understanding of the basic optical processes in semiconductors, dielectrics and organic materials. The application of such materials in systems composed of waveguides, light emitting diodes and lasers, as well as modulators is developed.

Course Description: Teaching photonics must start with plane wave propagation. However, before understanding plane waves in materials and free space, the applications of Maxwell’s equations must be presented. Wave equations and their properties can explain all of optics, including refractive optics. The propagation of waves through lenses then becomes straightforward since the student by now has mastered the concept of waves in materials. The effect of materials may be a simple incorporation of the index of refraction or it may necessitate derivation of non-linearities in material properties. In fact non-linear optics becomes a major component of the course.

The physics of lasers is presented so the student may understand and even eventually design lasers in crystals and semiconductors. The degradation mechanisms of VCSELs will be covered. This presents a dilemma since 3 and 4 level systems must now be developed for semiconducting heterostructures. The heterostructures and the physics of quantum wells result in confined states and hence transition rate equations may now be derived. The only difference is the inclusion of the density of states. However, with semiconductors the presentation must include the vertical surface emitting laser, where the emission wavelength may be band gap engineered. The stability of these multilayers becomes important in reliability prediction.

Photonics must be presented in the context of reliability. The design concepts must include material combinations which are robust and reliable. All wearout mechanisms must be understood, as well as to the effect on performance. Metallizations and their degradation mechanisms must be understood. Since heterostructures are present in photonics, their ultimate stability becomes very important.

Prerequisites: The students should have as background an introductory course in reliability.
Course Goals:
1. Students understand propagation of waves through lenses and materials and how this can be used to develop devices
2. Students understand what a laser is and how lasers work.
3. Students understand the concept of reliability with respect to photonics including mechanisms responsible for wearout and other types of failure.

Student Outcomes covered by the Course:
ABET A: Ability to apply mathematics, science and engineering principles;
ABET E: Ability to identify, formulate and solve engineering problems

Topics Covered:
Electromagnetic Waves
Optical Ray Propagation
Gaussian Beams
Optical Fibers and Optical Resonators
Optical Processes in Materials
Lasers and Laser Systems
Non-Linear Optics and Non-Linear Optics Materials
Physical Processes for Optical Detection
Characteristics of Photo Detectors
Modulation of Laser Beams
Semiconductor Lasers and Light Emitting Diodes
Double Heterojunction and Vertical channel Surface Laser
Vertical Channel Emitting Laser
Failure Mechanisms of Optoelectronic Devices and Metallizations
Failure Mechanisms in Photonic Devices