SEMICONDUCTOR LASERS
(OSE6536, 3 CREDIT HOURS)

INSTRUCTOR: SASAN FATHPOUR

SPRING 2020; TUES. & THURS. 1:30-2:45 PM; ROOM: CREOL A214
OFFICE HOURS: TUESDAYS, 3:00-4:00 PM, RM A216

CATALOG DESCRIPTION
This course covers the light-matter interaction, thermal physics and solid state physics needed to understand, analyze, and engineer semiconductor lasers with different active region dimensionalities.

COURSE GOALS
The course complements the OSE graduate courses on 'fundamentals of optoelectronic devices', 'integrated photonics' and 'optical communication systems' to deepen students' education in photonic engineering. The course's goal is elucidating the key principles underlying the analysis and design of semiconductor lasers, with an emphasis on the engineering and practical aspects of them. The students should attain basic understanding and design capability for advanced semiconductor lasers, at the end of the course.

COURSE APPROACH
In order to analyze and design semiconductor lasers, it is necessary to study the components that constitute them, the principles that underlie their operation, and their functional characteristics from the perspective of a device engineer. To this extent, the course begins with a broad phenomenological approach to generic diode laser principles. It then gets into advanced discussions on semiconductor band theory, and optical gain and dynamic effect in diode lasers. The course ends with analysis of advanced laser structures commercially in use and brief discussions on potential future directions.

PREREQUISITE
- Graduate Standing, OSE 5414, or Consent of Instructor:
  - Basic knowledge of photonics, lasers and semiconductors at the undergraduate level
  - Knowledge of optoelectronics at graduate level (OSE5414 Fundamentals of Optoelectronics) and basic quantum mechanics

REQUIRED READINGS:
Course Website:
https://webcourses.ucf.edu/courses/1268726

PRIMARY TEXTBOOKS:
- S. L. Chuang, *Physics of Photonic Devices*, 2nd Ed., Wiley, 2009.
- L. A. Coldren, S. W. Corzine, and M. Masanovic, *Diode Lasers and Photonic Integrated Circuits*, 2nd Ed., Wiley, 2012.

AUXILIARY TEXTBOOK:
- P. Bhattacharya, *Semiconductor Optoelectronic Devices*, 2nd Edition, Prentice Hall, 1997.

COURSE OUTLINE

1. Overview of Semiconductor Lasers

2. Phenomenological Modeling of Generic Diode Lasers
   - Photon and carrier density rate equations
   - Threshold and lasing conditions
   - Light-current characteristics

3. Electronic Band Structures in Semiconductors
   - Primer of lattice structures and quantum mechanics
   - Empty lattice of nearly free electron band structure
   - Kronig-Penney model
   - Pseudopotentail method
   - Kane's model
   - ***k*.*p*** model with spin-orbit interaction
   - Band structure of semiconductor quantum wells
   - Effect of strain on quantum wells
   - Band structure of superlattices

4. Gain and Current Relations
   - Radiative transitions, Matrix elements and Reduced density of states
   - Optical gain, lineshape broadening and gain spectrum
   - Spontaneous emission and Purcell effect
   - Nonradiative transitions
   - Active material characteristics

5. Dynamic Effects
   - Small-signal analysis of the rate equations
   - Large-signal analysis of the rate equations
   - Relative intensity noise
   - Linewidth enhancement factor and chirping
   - Carrier transport and feedback effect
   - Injection locking

6. Advanced Semiconductor Lasers
   - Distributed feedback (DFB) lasers
   - Vertical-cavity surface-emitting lasers (VCSELs)
   - Tunable and externally-modulated lasers
   - Quantum cascade lasers
   - Microcavity lasers

GRADING

Homework Assignments: 30%
Midterm Exam: 30%
Final Exam or Project: 40%

University Rules on Professionalism and Ethics
Per university policy and plain classroom etiquette, mobile phones, etc. must be silenced during all classroom lectures, unless you are specifically asked to make use of such devices for certain activities.

Academic dishonesty in any form will not be tolerated. If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule, the University of Central Florida's Student Handbook (http://www.goldenrule.sdes.ucf.edu/) for further details. As in all University courses, The Golden Rule Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and the student receiving a zero on the work in question at a minimum. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

Students with Special Testing/Learning Needs
Students with special needs and require special accommodations must be registered with UCF Student Disability Services prior to receiving those accommodations. Students must have documented disabilities requiring the special accommodations and must meet with the instructor to discuss the special needs as early as possible in the first week of classes. UCF Student Disability Services can be contacted at http://www.sds.sdes.ucf.edu/, or at (407)823-2371.

Academic Ethics Specific to This Lab Course
It is the nature of a laboratory course that you will be working in groups. Obviously, those of you who are lab partners will be using the same raw data. You are encouraged to discuss your observations and insights with your lab partners; however, each of you has to write your own ORIGINAL lab reports.

Cheating and plagiarism are serious breaches of the UCF Code of Honor as described in the UCF Golden Rule and the UCF Creed, and will not be tolerated in this course. All cases will be reported to the Office of Student Conduct (OSC).

Definitions
Cheating: any unauthorized assistance in graded, for-credit assignments.
Plagiarism: appropriating the work of others and claiming, implicitly or explicitly, intentionally or unintentionally, that it is your own.

With increased use of the internet, digital plagiarism is becoming more of a problem on campuses everywhere. You are encouraged to use the internet; however, electronic copying and pasting of material directly into reports and papers without proper reference of the source is blatant plagiarism. **Always reference the sources of information.**

Providing a fellow student with experimental data from an experiment in which he/she did not participate is also forbidden. All parties that are involved in such practice will be reported to UCF Office of Student Conduct (OSC).

If there is any question concerning acceptable practice in this laboratory course, do not hesitate to ask the instructor.